Urban Water Security in the City of Windhoek

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Declaration

I, the undersigned, hereby declare that the work contained in this assignment is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature: ………………………………………….   Date: ………………………………..

Abstract

Urbanisation is a complex phenomenon and is a trend witnessed across the globe. Africa particularly has been experiencing the world's most rapid rate of urbanization and cities are faced with the resulting pressure on natural resources. Water is one of the resources under pressure and the provision thereof is complicated by the deteriorating quality and quantity thereof.

This study takes a brief look at the water situation in a water scarce region in Africa and concentrates on the urban water supply sector. It takes an in depth look at the measures used to secure water supply to a city in this very dry part of the world.

The area under study is Windhoek, the capital of Namibia, situated in the southwestern corner of Africa. Namibia is the driest country in Sub-Saharan Africa and is characterised by a semi-arid nature, which results in a very hot and dry climate with erratic rainfall patterns. Windhoek has a low average rainfall associated with very high evaporation rates. No permanent water bodies exist near the city and the bulk of Windhoek's water supply comes from storage dams quite a distance from the capital. Most of these sources of supply have been developed and are nearing the limit of their potential. A desperate need therefore exists to develop reliable additional water resources to secure the water supply especially during periods of prolonged drought.

The case study gives examples of the initiatives taken by water authorities to improve the security of supply and keep up with the growing demand in the city. These initiatives include a dual pipe system for the distribution of semi-purified sewage for irrigation, reclamation of domestic sewerage, aquifer recharge and the implementation of Water Demand Management principles.

An analysis of the most efficient and cost-effective means of supply augmentation namely aquifer recharge, have been balanced against the potential water savings of Water Demand Management in the city. The study also takes a brief look at the principles of Integrated Water Resource Management and how it is incorporated in the strategies used to augment supply to the city.

The research found aquifer recharge as the most efficient and cost-effective means to augment supply to the city and together with Water Demand Management creates an approach complying with the goals of Integrated Water Resource management. The study concludes by identifying gaps in demand management in

the city. It also suggests relevant recommendations on how to increase the effectiveness of Water Demand management.

Opsomming

Verstedeliking is ‘n komplekse verskynsel en ‘n tendens wat regoor die wêreld voorkom. Die hoogste voorkoms van verstedeliking vind in Afrika plaas wat groot druk plaas op die natuurlike hulpbronne van stede.

Water is een van die hulpbronne onder druk en die voorsiening daarvan word bemoeilik deur die verswakking van die kwaliteit en die beskikbaarheid daarvan.

Hierdie studie konsentreer op die watersituasie in ‘n waterskaars streek in Afrika en die stedelike watervoorsieningssektor. Dit behels ‘n in diepte ondersoek na metodes wat gebruik word om die watervoorraad van die stad te verseker in hierdie droogte gesteisterd deel van die wêreld.

Die gebied onder bespreking is Windhoek, die hoofstad van Namibië, wat geleë is in die Suidwestelike deel van Afrika. Namibië is die droogste land in die Sub-Saharastreek en word gekenmerk deur gereelde droogtes met ‘n gepaardgaande warm droë klimaat en onreëlmatige reënvalpatrone. Windhoek word gekenmerk deur ‘n lae gemiddelde reënval met ‘n baie hoë verdampingstempo. Geen permanente waterbronne kom in die nabyheid van die stad voor nie en die watervoorraad word gestoor in opgaardamme wat redelik ver van die hoofstad geleë is.

Hierdie voorsieningsbronne is voortdurend in gebruik en die voorraad is beperk. Daar onstaan dus ‘n dringende behoefte aan betroubare bykomende waterbronne om voortdurende voorsiening aan die stad te verseker veral gedurende aanhoudende droogtes.

Die gevallestudie konsentreer op voorbeelde en inisiatiewe wat deur die Water Owerhede geneem word om die voorsiening van water, aan die immergroeiende behoeftes van die stad te verbeter en te verseker.

Hierdie pogings sluit in,‘n dubbele pyplynsisteem vir die verspreiding van halfgesuiwerde rioolwater vir besproeiingsdoeleindes, herwinning van huishoudelike rioolwater, herlaai van ondergrondse watervoorraad en die implimentering van wateraanvraag bestuursmaatreëls.

Die geskiktste en mees koste-effektiewe metode van verhoogde watervoorsiening naamlik die herlaai van ondergrondse waterbronne, is ontleed, en die voordele

opgeweeg teen die potensiële waterbesparing deur die Bestuur van Wateraanvraag in die stad.

Daar is ook kortliks gekyk na die beginsels van Geintigreerde Water Bronne Bestuur en hoe dit by bestaande strategieë ingelyf is om uitbreiding van voorsiening aan die stad te verseker.

Die navorsing het bevind dat die herlaai van ondergrondse waterbronne as die geskikste en mees koste-effektiewe metode beskou kan word om die verhoogde aanvraag van die stad die hoof te bied.

Die studie word afgesluit deur die tekortkominge in die Water Aanvraagbestuur van die stad te identifiseer. Relevante aanbevelings word gemaak van hoe om die effektiwiteit van hierdie betrokke strategie te verbeter.

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List of Acronyms & Abbreviations

CoW	City of Windhoek [Windhoek Municipality]
GWWTP	Gammams Waste Water Treatment Plant
ICID	International Committee for Irrigation and Drainage
IWRM	Integrated Water Resource Management
MDG	Millennium Development Goal
Mm^3	Million cubic metres [same as million (kg) kilolitres]
$Mm^{3/}a$	Million cubic metres per annum
NamWater	Namibia Water Corporation
NDP	National Development Plan
NGWRP	New Goreangab Water Reclamation Plant
NNWB	Namibia National Weather Bureau
NSOTER-SA	National State of the Environment Report-South Africa
N$	Namibian dollar [1 N$ = 1 SAR]
NWPS	New Western Pump Station
PPA	Participatory Poverty Assessment
PRS	Poverty Reduction Strategy
SARPN	South African Regional Poverty Network
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNCHS	United Nations Centre for Human Settlements
WDM	Water Demand Management
WSSD	World Summit on Sustainable Development
WSM	Water Supply Management

1. Introduction

The world is becoming more and more urbanised and it is estimated that by 2050 nearly 75% of the world's population will be living in cities (Swilling, 2003). This uncontainable growth of cities puts a lot of pressure on natural resources and presents a big challenge for authorities in the managing of these resources. It is therefore safe to say that the management of water in urban areas is a complex issue and one that needs a fair amount of attention. To attain urban water security in cities a priority must be to control water demand in serviced areas while providing safe drinking water to the informal areas.

Windhoek is the capital city of Namibia and is located on the central highlands approximately 1650m above sea level. The central area of Namibia is characterised by a low average annual rainfall and a very high rate of evaporation both contributing towards the arid climate found in and around the city of Windhoek. The city is further plagued by rapid urbanisation and a very erratic rainfall pattern. Securing water supply for the city of Windhoek is therefore an immensely challenging task. What complicates matters even further is the fact that no permanent natural water bodies exist near the city and water needs to be transported over long distances to supply the city with water. Most of the existing underground water sources in and around the city have been developed and are nearing the limit of their potential. An urgent need therefore exist to develop reliable additional water resources to secure the water supply in the long run and especially during periods of prolonged drought.

This assignment takes an in-depth look at ideas and measures implemented by water authorities in Windhoek aimed at ensuring a security of supply to the city's residents. The study also takes a brief look at other possible strategies and the feasibility thereof. An evaluation of aquifer recharge as an augmentation scheme balanced against the potential water savings from Water Demand Management (WDM) in the city is also presented to illustrate how water security can be improved.

Water demand management has proved itself to be an important strategy in meeting the objective of using limited water resources as efficiently as possible. The main objective is to curb demand by increasing the public's awareness of water scarcity but still stimulate social and economic development. The local authorities in the city of Windhoek have been keenly working towards reducing water demand through the implementation of a thorough water demand management strategy in the serviced areas. This effort however seems to be futile due to the fact that it is only actively pursued in times of water shortages. This paper therefore also takes a look at what should be done for WDM to have a bigger effect on water consumption in the city.

2. A background to sustainable water supply and associated problems

2.1 Background

Global economic growth, population increase and urban expansion are all driving energy consumption and water use to record levels. Increased urbanisation in particular is placing an enormous strain on existing water and sanitation infrastructure. In addition to the above, uncontrolled growth in large cities is rapidly changing the face of the earth causing the pressure exerted on natural resources to increase dramatically. Problems of a social, economic and environmental nature seems to multiply swiftly and if not managed sensibly, could be detrimental to both society and nature.

Table 1: Distribution of urban population in more and less developed regions

Year	1975	2000	2015
More developed regions	734 millions 70%	898 millions 75.4%	954 millions 78.6%
Less developed regions	809 millions 26.8%	1,964 millions 40.4%	2,915 millions 48.6%

Source: UNESCO, 2003a

In the past century the global urban population has expanded from 15 per cent in 1900 to nearly 50 per cent in 2000. Furthermore, it is estimated that by the year 2050, nearly 75 per cent of the global population will be living in cities (Swilling, 2003). This trend (Table 1) is even more evident in developing countries, where the rate of urbanisation is currently extremely high due to the lag behind of developed countries, where this phenomenon already took place during the middle of the previous century. Africa particularly has been experiencing the world's most rapid rate of urbanization at nearly 5 per cent per annum. Deteriorating conditions in rural areas together with presumed urban possibilities attract people to urban agglomerations. Cities have become magnets for people seeking a better life, and an escape from a situation that is perceived as underprivileged and less attractive. The major problem is that bigger cities within these developing countries rarely have the infrastructure and vision to support such a massive increase in population.

Despite the warning signals of the deepening of urban poverty and the growth of urban slums, researchers seem to agree that cities can offer great advantages

(UN-HABITAT, 2003a). Cities have the potential to combine safe and healthy living conditions with remarkably low levels of energy consumption, resource use and wastes (UNCHS, 1996:56). Among others, some of the advantages offered by cities is the fact that higher population densities means a much lower cost per household and per enterprise for the provision of piped, treated water supplies, the collection and disposal of household and human wastes, advanced telecommunications and most forms of health care and education (UNCHS 1996:56). Cities are also seen as important engines of economic growth and are often of great national importance especially in terms of socio-economic development and political decision-making.

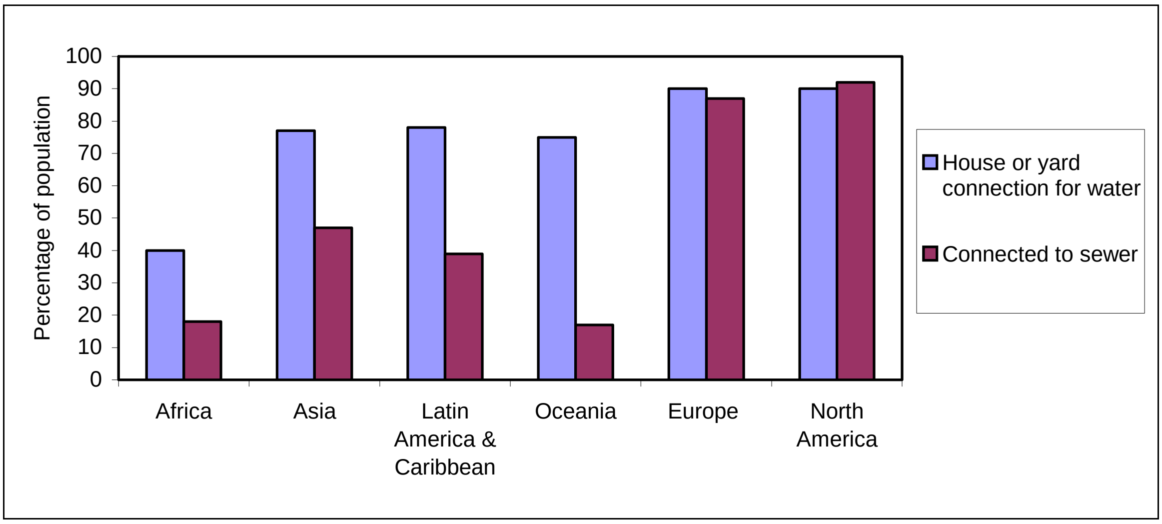
Overall, the general situation in cities in the South, encompassing rapid growth of informal areas, escalating water constraints in terms of quantity and quality, and at the same time a desperate need for social and economic development, makes the complex issue of urban water management highly relevant in the 21st century.

2.2 Water as an important resource

Being three very fragile and irreplaceable components of our existence, air, land and water should be given special attention and be managed very carefully to ensure sustainable future development. Of the above, water is certainly the most crucial element in human development and is essential to all social and economic activities. There is no doubt that water is vital to every form of life, and all human life depends on the supply of quality water in reasonable amounts. Yet more than 1.2 billion people have no access to hygienic, safe drinking water, and some 2.3 billion have to live without basic sanitation facilities. Water related problems are spreading and more than thirty countries today suffer acute water shortages (German News, 2005). Quality water and sanitation is very closely linked and both should be considered as the first priority in attending to the problems of poverty and urbanisation.

Worldwide, the problem in cities is one of over-consumption by the rich and under-consumption by the poor, especially when it comes to the usage of water. Well-off people tend to use as much as they need because they have the economic capacity to afford it. As a general rule this group of people also have easier access to potable water in the form of taps in their homes. Poorer people living in informal squatter areas have to make do with communal water points and the per capita use of water is much less than in the higher income neighbourhoods. This tendency is illustrated in figure 1 below which shows the proportion of households in major cities connected to piped water. In the graph it is evident that cities in less developed countries have a smaller portion of households connected to piped water. This is mainly because more informal settlements exist in these cities than in cities in developed countries.

Figure 1: Proportion of households in major cities connected to piped water and sewers



Source: UNESCO, 2003b

While the global picture is far from encouraging, the situation in Africa is even worse. On most indicators on the provision of water, sanitation and human settlements, progress remains slowest in the world's poorest region. In many African nations the demand for water is rising and together with the highly variable climate, reliable provision of water is an intimidating task and calls for sound management strategies of the limited or highly variable water resources available. Over the past ten years, Africa alone has experienced nearly one-third of all water-related disaster events that have occurred worldwide, with nearly 135 million people affected, 80% by droughts (Africa Renewal, 2004). It is one thing to realise the threat which water scarcity pose, but it is quite another to mobilise the potential of water to ensure that it does not become a constraint for sustainable development. Decision and policy makers therefore need to keep in mind that the correct approaches need to be taken, so that economic and social development do not negatively impact water resources, and that this in turn constrain future development efforts (SARPN, 2004).

In developing countries, the rapid influx of people into the cities puts even higher pressure on the natural resources and local authorities struggle to handle the sudden influxes. Typically, authorities in developing countries in Sub-Saharan Africa struggle with the critical issue of a consistent, reliable water supply. Lots of examples exist of strategies put into place to narrow the gap between water supply and demand. In many cases water authorities have prioritised investments in large-scale water infrastructure instead of trying to control water demand. However, the answer to long-term urban water security lies not only in the increase in bulk water supplies, but also in the management and adjustment of demand according to the available resources.

2.3 The international agenda

There are a number of national and international agreements and development goals that highlight the need for water supply improvements and to control the development of water demand in urban areas. The UN Millennium Development Goals (UN, 2005) set the target to reduce the number of people without sustainable access to safe drinking water and sanitation in half by 2015. The UN Water for Life Decade (2005 – 2015) report estimates that by the year 2025 approximately 3.4 billion people will be living in countries defined as water-scarce. At the Second World Water Forum in The Hague in 2000, the African Water Vision for 2025 was adopted (Magnusson, 2005:18). The primary goals of this vision are to improve the motivation and skills of water professionals and to ensure that water pricing promotes equity, efficiency and sustainability.

At the World Summit on Sustainable Development in Johannesburg 2002, it was concluded that the keywords of water management must be: improved access, improved efficiency, better watershed management and reduced leakage (WSSD, 2002).

The objectives of the UN-HABITAT Water for African Cities Programme is to tackle the urban water crisis in African cities through efficient and effective water demand management, build capacity to mitigate the environmental impact of urbanisation on freshwater resources and boost awareness and information exchange on water management and conservation (UN-HABITAT 2003b). It also aims to promote the exchange of best practices in urban water management in support of the implementation of *the Habitat Agenda*. Most of these documents are related to urban growth, water and development. Part of the UN Millennium Development Goals is to achieve significant improvement in the lives of at least 100 million slum dwellers by 2020 (UN, 2005). To achieve this improvement in the quality of life of people, the provision of safe drinking water certainly should be the basic starting point.

The international agenda perceives water and related issues as important for future development. As mentioned previously, water is an important contributor to a good quality life and without it life simply is not possible. Water management in developing cities is a complex and dynamic challenge and sound management strategies are needed. It is complex in terms of the many parties and stakeholders that need to be taken into consideration and dynamic in terms of the continuous change of socio-economic settings that takes place in a city.

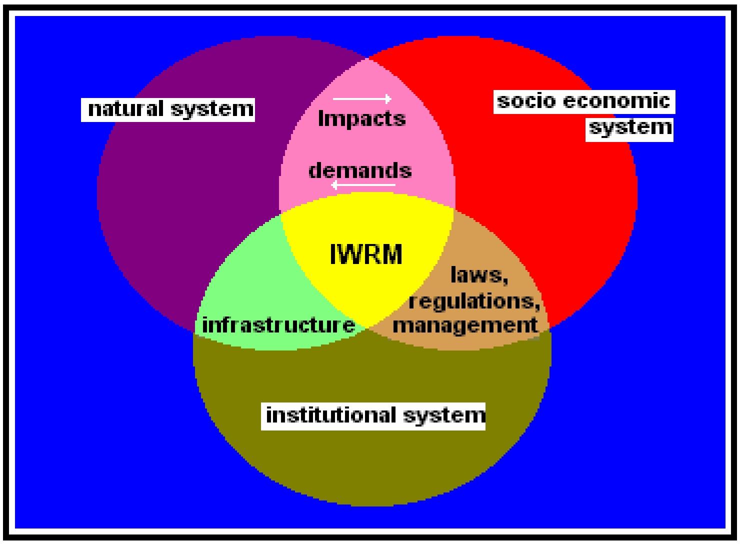
2.4 Integrated Water Resource Management (IWRM)

To be able to effectively sustain economic growth, population growth, water demand growth and water as a scarce resource, an integrated water resource management approach (IWRM) is needed. IWRM is based on the perception of water as an integral part of the ecosystem, a natural resource and social and economic commodity, the quantity and quality of which determines the nature of its utilisation.

According to Van Beek (cited in Poolman 2004:3), IWRM is: "a process that promotes the co-ordinated development and management of water and land related (natural) resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."

Figure 2 below represents an illustration of the IWRM concept. It demonstrates the natural resource system (NSS), the social economic system (SES), the administrative institutional system (AIS) and the links between them.

Figure 2: The Water Resources System of IWRM



Source: Adapted by the researcher based on data from Van der Merwe, 2005

An important purpose of water management is to match or balance the demand for water with its availability through suitable water allocation arrangements (Poolman 2004:3). Management of water's availability is referred to as Water Supply Management (WSM), while management of the demand is referred to as Water Demand Management (WDM). However, there is an important difference between these two. According to Van der Merwe (Interview, 2005), "demand management is the use of economic and legal incentives in combination with awareness raising and education to achieve more desirable consumption patterns, both in terms of distribution between sectors and quantities consumed. Supply management looks more at achieving and sustaining a security of supply by finding (or creating through augmentation schemes) and utilising more sources of water."

In the long-term, WDM is therefore a much more sustainable approach than WSM because the focus is on trying to match the demand with the available supply rather than trying to augment the supply in order to keep up with the growing demand. Good water management therefore is a process of integrated demand and supply management which seek to match supply with demand through reducing water losses, increasing water yield and decreasing the demand of water.

2.5 Relevance of case being studied

Namibia is an example of a rapidly developing country that struggles with the associated problems of poverty and urbanisation in its quest to reach its development potential.

Poverty eradication has therefore been at the centre of Namibia's national development policies and strategies. In 1998, two years before the Millennium Development Goals were agreed upon, Namibia adopted a Poverty Reduction Strategy (PRS), followed by a comprehensive Poverty Reduction Action Programme, covering the period 2001-2005. This programme is based on Namibia's key strategic documents, the Second National Development Plan (NDPII), and Vision 2030, both of which are compatible with the MDGs. As part of implementation of the Poverty Reduction Programme, Namibia has recently launched and embarked upon a Participatory Poverty Assessment (PPA). The Assessment exercise has already been completed in three of the country's thirteen regions and is currently being extended to the remaining regions. The outcome of these assessments will be utilised in the formulation of the Third National Development Plan (NDPIII) 2006-2011 as well as the Regional Development Plans.

Together with the common problems which developing countries are faced with, Namibia especially has a huge task coping with extreme water scarcity. Policy makers and planners in this dry part of the world therefore need to give extra special attention to the issues of water and sanitation. As mentioned, one of the Millennium Development Goals is to reduce the number of people without sustainable access to safe drinking water and sanitation in half by 2015. The Government of Namibia in particular made good progress in this regard, in which the target as set out in the Second National Development Plan of providing 80% of the rural and 95% of urban population with safe drinking water by 2006, has already been achieved. The problem therefore seems not be the provision of the service as such, but rather the vulnerability and scarcity of the resource.

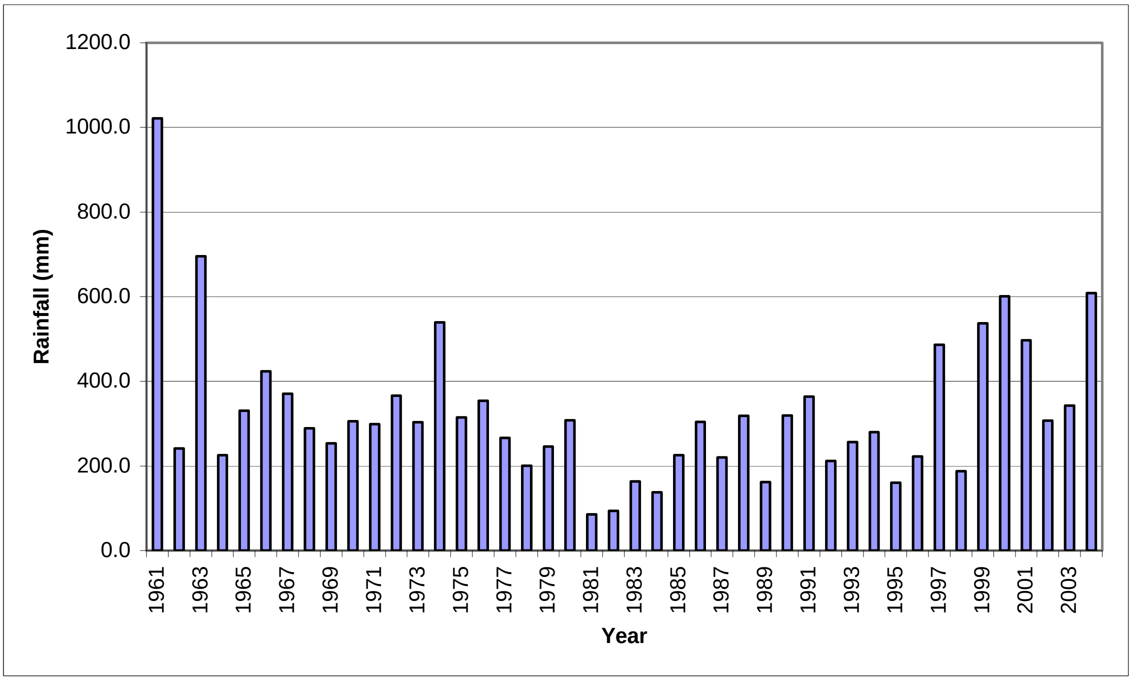
Integrated Water Resource Management in Windhoek therefore is an important phenomenon and requires ongoing attention to augmentation of the existing supplies (which means looking at the natural and institutional dimensions) and the efficiency of water utilisation (which means looking at the socio-economic and natural systems) in order to meet the growing demand while keeping in mind and realising the vulnerability of the finite resource. This study will investigate the way in which the City of Windhoek makes use of the IWRM system in an attempt to meet demand with supply and ensure water security in the long term.

3. Research and Methodology

3.1 Statement of the Research Problem

Namibia is the driest country in Sub-Saharan Africa making water an extremely scarce natural resource. The central area in which the capital city Windhoek is located generates the biggest demand on the available local water resources. This poses a major challenge to authorities to secure water to all sectors. This is further complicated by the fact that no permanent water bodies exist in the immediate surroundings of the city and most of the other local and regional water sources within the central area have been developed and are nearing the limit of their potential. Despite this, the city is undergoing a major developing phase with a sudden influx of people from rural areas. Statistics show tremendous growth in the city’s population over the past 15 years since independence was gained in 1990 and future prospects indicate even more rapid growth.

Figure 3: Historic Rainfall in Windhoek



Source: Compiled by researcher based on data from the NNWB, 2005

Figure 3 shows the historic annual rainfall figures for the City of Windhoek (See Appendix A for actual data). The infrequent and erratic rainfall pattern is clearly visible with some years having more than a 1000 mm of rain while in other years the rainfall was below a 100 mm in total. This unpredictable rainfall patterns renders it almost impossible for authorities to secure a reliable natural water source. The inconsistent rainfall coupled with the almost exhausted water supplies in the locality of the city presents an enormous challenge to the City Council of Windhoek to ensure water security in the long run.

3.2 Research Objectives

The main objective of this research is to analyse the means and strategies implemented by water authorities in Windhoek aimed at ensuring security of supply to its residents. The study will also take a brief look at other possibilities and the feasibility of these strategies. An analysis of the most efficient and cost-effective means of supply augmentation will be compared with the potential water savings of Water Demand Management in the city. This idea is to create a fresh awareness of the different ways of meeting water supply against the ever-growing demand in the water scarce city of Windhoek and thus sustaining social and economic growth.

3.3 Research Questions

The following research questions were identified that need to be answered in order to try and satisfy the above objectives.

- What are the current strategies used by water authorities to supply water to the city's residents?
- What is the current and future water demand of the city?
- Which of the identified strategies are the most efficient, cost-effective and sustainable?
- Is Water Demand Management used to its fullest potential to curb demand?
- What can be done to increase the effectiveness of Water Demand Management?
- What other possibilities, not currently implemented, are there to augment supply to the city?
- How effective is the Integrated Water Resource Management strategy?

3.4 Study and Methodology

3.4.1 Selection of Research Strategy

The choice of a research strategy in general determines the method of data collection, subsequent analysis and presentation thereof.
According to Yin (1994:4) the most important aspect to consider when selecting a research strategy is to identify the type of research questions to be asked in the

case study. These questions will guide the researcher and form the foundation of the research. Typically the questions also act as reminders throughout the investigation regarding the information that needs to be collected and will mainly be based on "what" needs to be investigated, "how" one is going to investigate the research problem and "why" one is doing the investigation or research. Table 2 below shows how the type of research questions is related to the type of research strategy to be selected.

Table 2: Relevant situations for different resource strategies

Strategy	**Form of research questions**	**Requires control of behavioural events?**	**Focuses on contemporary events**
Experiment	How, Why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival Analysis	Who, what, where, how many, how much?	No	Yes/No
History	How, Why?	No	No
Case study	How, Why?	No	Yes

Source: Yin (1994:5)

This study makes use of the *case study research method* as part of a multi-method approach in which the same dependent variable is investigated using multiple additional procedures (Tellis 1997:1). The case study strategy is most likely to be appropriate in answering the "how" and "why" questions. As mentioned, this research methodology consists of a set of predetermined research questions driving the researcher towards formulating an academic paper aimed in a specific direction. Yin (1994:12) further stipulates that the essence of a case study is that it tries to illuminate a decision or a set of decisions, why they were taken, how they were implemented and with what result. He also mentions that a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident.

According to Tellis (1997) case study research is not sampling research. However, selecting cases must be done so as to maximize what can be learned, in the period of time available for the study. Tellis also (1997) states that this method ensures the transformation from the local to the global for explanation. Case study research can be viewed as to satisfy the three tenets of the qualitative method: describing, understanding, and explaining. Using this strategy the researcher is able to analyse a unique case and provide relevant recommendations. This method also assists the researcher in describing the situation to the reader while providing him/her with an understanding of the specific case.

In this assignment it takes the form of a single explanatory case study, designed to represent this very unique situation. As with most other research methods, the case study method does have certain disadvantages and one of them as described by Tellis (1997) is that its dependence on a single case alone renders it incapable of providing a generalised conclusion or a look at the 'bigger picture'. In addition to this the case study methodology tends to be very time-consuming and labour intensive as it requires a vast array of rich information in order to write up a case. This method also provides the unwanted opportunity for the researcher to over-generalise beyond cases similar to the one studied. It is also criticised as being highly subjective as it solely relies on the knowledge and experience of the researcher.

However, the case study methodology does present the researcher with a number of advantages. The biggest advantage as described by Tellis (1997) is certainly the flexibility of the method in comparison with experimental or quasi-experimental research. Furthermore the information provided is usually more concrete and contextual due to the in-depth analysis of the case being studied. Although not allowing generalisation, case studies can help other researchers to develop theoretical propositions on the relevant subject.

In this writing, the case study method is used to look at and analyse the finely balanced water situation in the city of Windhoek. It will give the reader a good indication of what is currently happening in the city and may influence other researchers to further explore different dimensions of this case.

3.4.2 Selection of the specific case

Having lived in Windhoek for the biggest part of my life, I am very familiar with the drought related problems the area often has to deal with. From an early age I was aware of the fact that water is a precious resource in the area and it was often stressed (especially during periods of drought) that it should be used sparingly. Being an absolute basic necessity for survival, I became inquisitive through the years of how exactly water planners in the city go about to ensure sufficient water supply for the ever increasing demand. One strategy I was aware of was the fact that Windhoek makes use of a reclamation plant to reclaim water from sewerage effluent. This is the strategy used by water authorities that almost every citizen in the city comes to know about some or other time. I believe this is mainly because of the psychological effect the drinking of reclaimed sewerage water tend to have on an individual.

As the issue of service provision is part of my studies in development planning, I saw it as a great opportunity to write my assignment on this interesting case. This gave me the opportunity to explore the initiatives and formulate an understanding of the daunting task water planners in this dry part of the world are faced with. As mentioned it may also present the opportunity for other researchers to develop theoretical propositions or to further explore other dimensions of the case.

3.4.3 Data Collection

According to Yin (1994) the process of data collection in the case study method is far more challenging than any other research strategy, as the case study collection procedure cannot be based on a regular routine. Unlike other research strategies where the procedure can be measured or even tested, the case study method does not have any "tests" to measure the degree of research to be taken. Yin (1994) further indicates that the researcher should however be able to ask good questions and understand the answers given by the respondent. The researcher should be able to listen to what the respondent is saying without having any preconceptions of what the answer should be. The researcher should also readily be able to act on possible opportunities that might arise out of the research in light of new findings. The researcher should fully understand what the research entails to make sure that the method used is directed in the right direction like asking the right questions in the correct manner. Finally the researcher should be unbiased by any preconceived notions in such a manner as to be open and receptive for any response of any nature, even if it opposes the current findings.

Another characteristic of the case study research methodology is the fact that huge amounts of data need to be collected and studied. Data for this assignment was mainly collected from the Windhoek City Council and the Namibian Water Corporation. This data comprised reports, articles, maps and interviews that were conducted with various actors of the two institutes. The interviews was based on questions surrounding water supply and the two words "how" and "why" enabled me to formulate quite a good understanding of the situation and strategies used in the city. The interviews took the form of focussed discussions and no real predetermined questions were asked the first time around. This forced me to probe issues deriving from the discussions, which eventually provided very rich and useful information. Some of the interviewees were interviewed a second and even a third time to clarify matters that were not clear the first time. This also provided the opportunity to pose more specific questions.

Data was also collected through searching the Internet and collecting literature relevant to the study. These data mainly comprised journal- and newspaper articles as well as statistical information obtained through government sites. Other various relevant stakeholders such as the National Weather Bureau and the Central Bureau of Statistics were also consulted to obtain statistical information.

Various site visits have also been done where photographs were taken to add more depth and add a visual dimension to the assignment. These photos focussed mainly on the study terrain and other relevant objects described in the assignment.

3.4.4 Data Analysis

According to Tellis (1997) this aspect of the case study methodology is the least developed and therefore the most difficult. Soy (1997) explains that the researcher examines raw data using many interpretations in order to find linkages between the research object and the outcomes with reference to the original research questions. She also argues that throughout the evaluation and analysis process, the researcher remains open to new opportunities and insights. The case study method, with its use of multiple data collection methods and analysis techniques, provides researchers with opportunities to triangulate data in order to strengthen the research findings and conclusions.

In order to make an accurate analysis Yin (1994:137) states that one must make sure that the data collected is of the best quality available and that all possible angles are covered. He mentions four basic principles that can be applied to ensure that the data collected is of the highest quality. The first principle is that the data collected should indicate that all the relevant evidence was collected and that none was left out or overlooked. This will ensure that the data collected will be acknowledged as being reliable and accurate. The second principle states that all major rival interpretations of your findings should be included in your research. If there is evidence to prove this rival then it should be mentioned along with its results. If there is no evidence to support this rival then the rival should be restated as a possible topic for future investigation. Thirdly, Yin states that the analysis should be directed towards the most significant aspect of the case study in order to address the largest issue (Yin, 1994:138). The fourth principle states that the researcher should include his/her own prior expert knowledge into the case study. This entails that the researcher should have analysed the data and come up with his/her own understanding of what the data actually means (Yin, 1994:139).

Taking the above-mentioned into consideration a wealth of data needed to be collected. In depth interviews, perusal of available documentation and general media research was required in order to compare findings so that the gaps and opportunities could have been identified. This created the opportunity to formulate an accurate analysis and conclude relevant and practical recommendations.

4. Background to Namibia

4.1 Introduction

Namibia is situated in the southwestern corner of the African continent and its neighbouring states are South Africa, Zimbabwe, Botswana, Zambia and Angola. Stretching from the Orange River in the south, to the Kunene River in the north, Namibia's western border is formed by the South Atlantic Ocean with a coastline of 1 572 km. Namibia's topographical terrain exists mainly of a high central plateau with the Namib Desert along the coast and the Kalahari Desert in the East. The semi arid nature of the country results in a very hot and dry climate with erratic rainfall patterns.

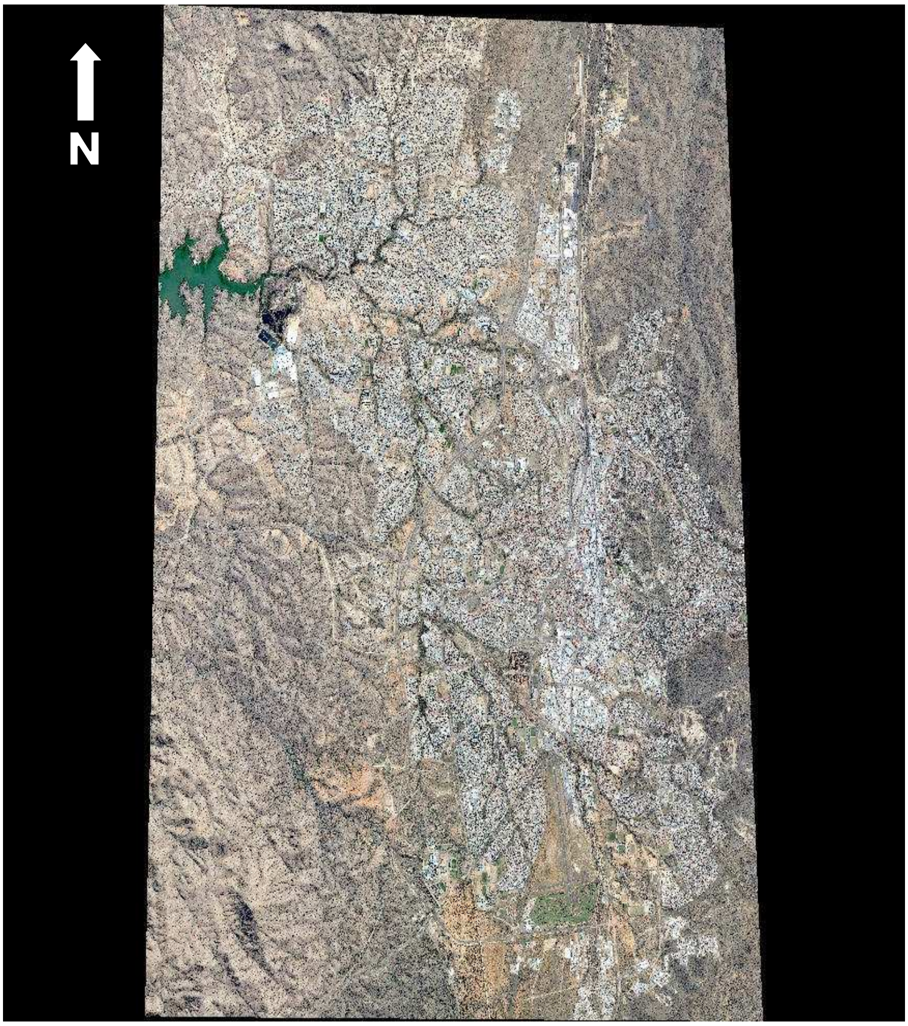
Namibia is one of the least densely populated countries in the world and covers a surface area of just over 824,000 km^2, which is a little bigger than Turkey or Pakistan, both of which have well over 50 million people. The population of Namibia is currently estimated at about 1.8 million resulting in a population density of less than two persons per square kilometre. With such a low population density it is hard to imagine that a city in Namibia is more or less faced with the same population pressures that beset so many countries and can undermine their pursuit of development on a sustainable basis (Gold *et al*, 2001:10). Namibia however, has a very low environmental capacity for sustaining human life and is the driest country south of the Sahara. Just over one third of the population live in urban areas (mainly in the capital city), but problems of resource availability and sustainability also apply there.

As Namibia's capital Windhoek is by far the biggest city in the country. According to the national population survey of 2001 the population of Windhoek is estimated at 233 529. In comparison it is more or less half the size of Bloemfontein, which is the sixth largest city in South Africa (Bloemfontein, 2005).

4.2 Windhoek as the capital

Windhoek is located in the Central Highlands of Namibia at approximately 1650m above mean sea level. The city lies in between mountain ranges in the South, East and West, forcing the city to expand towards the North. The hilly terrain complicates development and makes it difficult to develop in a sustainable manner. The total number of households in the city are about 58 580 with an average size of 4.2 persons per household (Census, 2001).

Figure 4: Aerial photograph of the developed area of Windhoek



Source: www.digitalglobe.com

The city is host to the central government, all ministries, the international airport and head offices of most of the economically active companies in the country. Based in the city centre is Namibia's financial centre, including the Bank of Namibia, the head offices of all the commercial banks, the very active Namibia Stock Exchange and the insurance industries. All foreign missions are found in Windhoek and the City is also the country's academic centre with the University of Namibia and Polytechnic of Namibia both located here (City of Windhoek, 2004).

According to the Namibian Economic Policy Research Unit (1996 cited in Windhoek Bulk Water Master Plan, 2004:1) Windhoek, in comparison with the total economic activity of the rest of the country, has 51% of manufacturing, 96% of utilities, 56% of construction and trade, 94% of transport and communications, 82% of finance and business services and 68% of community and social services in the country.

Windhoek's development up to independence was dominated by South Africa's apartheid policy with the concept of separate development. Thus caused the so-called "white" areas to obtain a well-developed infrastructure while the so-called "black" areas were left behind. Before independence in 1990 government policy forbade natural urban expansion in the "black" suburbs of towns. This resulted in grossly overcrowded conditions, often with an entire family living in one small room (Gold *et al*, 2001:3). This changed with the first fully democratic government, and people began moving out into their own homes–usually shacks on the periphery of towns. Others living in rural areas saw the opportunity to better their standard of living and loads of people migrated from these areas to the cities.

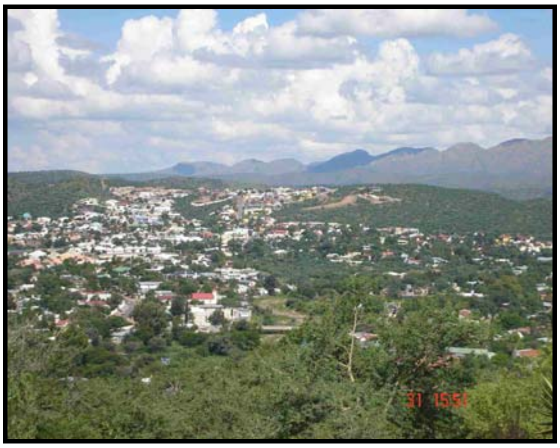
According to the national census survey of 2001, the average population growth rate of Windhoek is estimated at 4.44% per annum. One can just imagine how the demand on land, infrastructure and housing in the city has expanded over the last 15 years. From almost no informal settlements in 1990, the informal settlement area has mushroomed to just over 65 000 residents in 2002 (City of Windhoek, 2001b). With the estimated growth rate of 4.44%, the projected population of the city for 2031 is 800 000.

Against this background it is easy to imagine the pressure that this sudden influx of people placed on the natural resources of the city. This pressure however is not only on natural resources, but also puts a high demand on the economy, land, infrastructure and housing of the city. Although Windhoek is by far the most economically productive city in Namibia, there is no way it can keep up with the rapid rate of migration into the city. As a result, a very high rate of unemployment exists in the city. In order for Windhoek to grow in a sustainable way, the basic needs of all its residents, especially the poor people, need to be met. The Windhoek Development and Upgrading Strategy (City of Windhoek, 2001c) states that according to the Policy on Access to Land and Housing, the City Council recognises that access to secure land with communal water and sanitation provision is a first minimum step intended to lead on to concrete block housing, individual water and sewage drains, electricity and eventually tarred roads with storm water drainage. The inclusion of at least a communal water point as the first minimum step highlights the importance of the availability of safe water as a basic need for survival

4.3 Climatic conditions and the water situation in Windhoek

Generally speaking, Windhoek is a very hot and dry city with maximum average daily temperatures of 31 degrees centigrade in the summer. The hottest time of the year is from November to February. The highest rainfall months in the city are from January to March and rain comes in the form of heavy downpours associated with thunderstorms. The average annual rainfall for Windhoek is only 360 mm while the average evaporation rate amounts to 3 400 mm a year (NNWB, 2003). To put this in perspective, it is important to note that the global average annual rainfall is estimated at about 860 mm (NSOTER-SA, 2005)). The annual average precipitation of South Africa is 497 mm with an annual average evaporation rate of 2 000 mm (ICID, 2005). In other words, Windhoek has a lower rainfall by more than 100 mm of rain per annum and has almost twice the evaporation rate when compared with other dry countries.

Figure. 5 and 6: The hilly terrain in and around the city



Rainfall in the central area of Namibia occurs at infrequent intervals and no one knows how much, where or when it will rain. When it does rain, surface run-off tends to strip and erode the land because of the high intensity showers and hilly terrain (Figure. 5 and 6) in and around the city. According to the Department of Water Affairs (as cited in Gold *et al*, 2001) as much as 83% of the meagre rainfall evaporates before it reaches the ground, 2% enters drainage systems and only 1% recharges the ground water sources.

There are almost no natural permanent surface water bodies in the entire central part of the country, least of all near Windhoek. According to Gold *et al* (2001), the early development of towns and cities in Namibia centred on reliable water sources and Windhoek is such an example, being situated at the site of an artesian spring. In more recent years however, the expansion of the capital city has outgrown the local water supplies making it necessary to import water over long distances. In fact, the bulk of Windhoek's water supply comes from storage dams quite a distance from the capital.

4.4 Water supply to Windhoek

The main source of water supply to Windhoek is the Eastern National Water Carrier of which NamWater is the "owner". This is a pipeline that connects the Omatako dam in the north and the Swakoppoort dam in the west with the Von Bach dam located in the central area.

Other important water sources to the city are boreholes from which groundwater is abstracted and the New Goreangab Water Reclamation Plant (NGWRP), both of which are owned by the City of Windhoek (CoW). Despite having its own water resources, the City of Windhoek buys most of the bulk water from NamWater. The water the CoW supplies to its residents is a blended mixture of water from surface dams, boreholes and reclaimed wastewater. Biannually the City of Windhoek together with NamWater decides on the quota of water to be used over the following two-year period. According to Esterhuizen (Interview, 2005) the current figure stands on 21 Mm^3/a. This 21 Mm^3 is made up of 1 Mm^3 from boreholes, 5 Mm^3 from the reclamation plant and 15Mm^3 from natural occurring surface water in reservoirs owned by NamWater. The water supplied by NamWater from the Von Bach Water Treatment Plant is pumped directly into a terminal reservoir located in the city (Burger, 2004). Water is then transferred from the terminal reservoir and blended with reclaimed water from the NGWRP to the required ratio at the so-called New Western Pump Station (NWPS). This pump station (Figure. 7 and 8) fulfils the function of a main blending and distribution pump station in the bulk water supply system to the city of Windhoek (Burger, 2004).

Figure. 7 and 8: The New Western Pump station in Windhoek

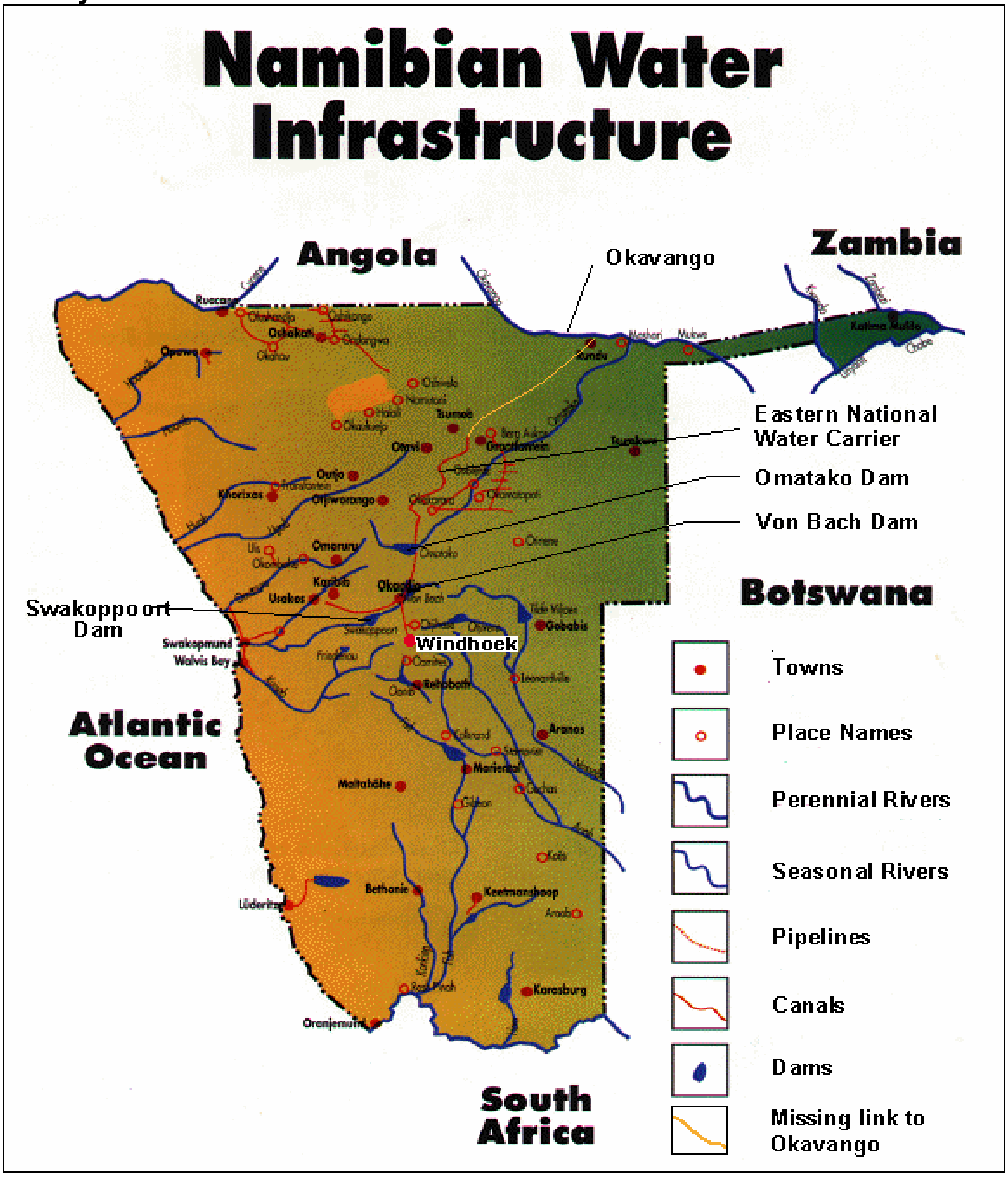
The bulk water supply system in the city consists of 15 pump stations, 19 closed storage reservoirs (Figure 9. and 10) and approximately 112 km of pipelines (Windhoek Bulk Water Master Plan 2004).

Figure 9. and 10: Some of the closed reservoirs in the city

As already mentioned, the three dams supplying the bulk of the city's water are the Von Bach Dam (48.6 Million cubic metres (Mm^3)), the Swakoppoort Dam (63.5 Mm^3) and the Omatako Dam (43.5 Mm^3). The distances to the three dams are 70, 100 and 200 km respectively (Figure 11). When operated together, the safe yield of the three dams is approximately 20 Mm^3/annum based on a 95% assurance of supply (Drews, Interview 2004). However, due to erratic inflow into the three dam system in the past, chronic water shortages have been experienced in Windhoek since 1990.

The only two dams that exit in the ephemeral rivers near the city are the Avis Dam (2.4 Mm^3) and the Goreangab Dam (3.6 Mm^3). The 95% assured yield of these two sources is estimated at approximately 1.1 Mm^3/annum (City of Windhoek, 2004b: 16). According to Burger (2004) the safe yield of the Avis dam is accepted as zero due to unreliable inflow. For this obvious reason the dam cannot be used for water supply to the city.

Figure 11: Map of Namibia highlighting most important sources supplying the city of Windhoek



Source: Vatech, 2004b

At the Goreangab dam a water reclamation plant was built in 1968 aimed at reclaiming potable water directly from domestic sewage. This concept despite early social inhibition was hugely successful and resulted in the construction of the New Goreangab Water Reclamation Plant (completed in July 2002) as an upgrade of the old reclamation plant (Cronje, Interview 2004). The NGWRP is recognised as one of the largest of its kind in the world with a design capacity of 7.7 million cubic metres of reclaimed potable water per annum (Mm^3/a). As well as being the cheapest source of augmentation, the reuse of water does not impinge on primary sources such as surface reservoirs or groundwater. A strategy used by the Windhoek municipality (City of Windhoek) is to blend the reclaimed water with pure water from the Von Bach dam. According to Burger (2004), the blending ratio is limited to a maximum of 35% reclaimed water to 65% water from the Von

Bach dam. He added by saying that although not recommended, this blending ratio could be increased to higher ratios in times of emergency supply.

The City of Windhoek also operates several groundwater schemes which constitute the third source of supply of water to the city (De Waal, Interview 2004). A large number of boreholes situated in the southern part of Windhoek supply water directly into various reservoirs.

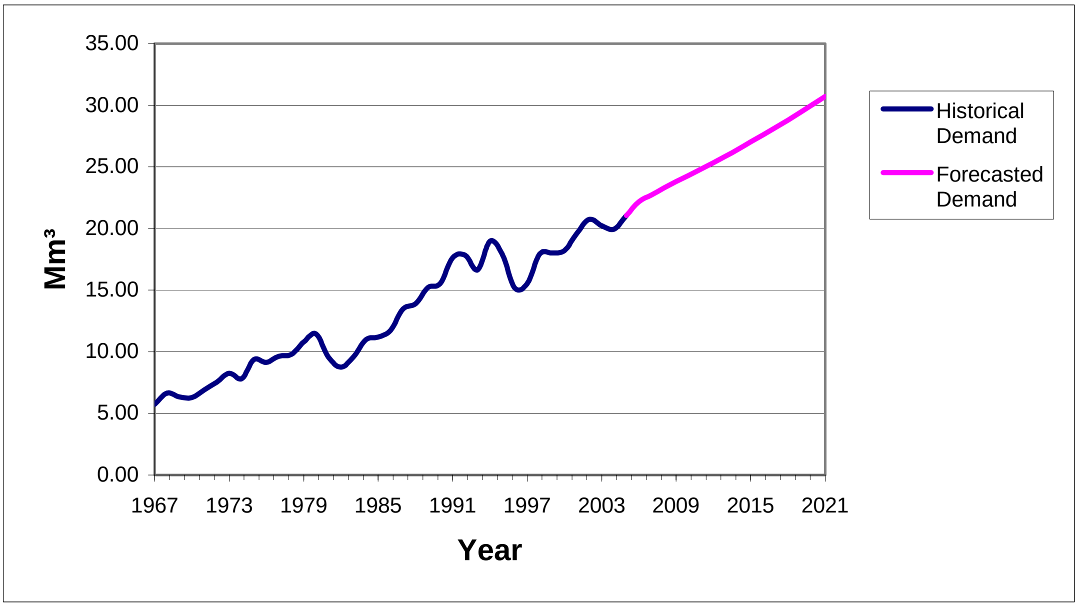
It is foreseen that with the sources of the water system nearing the limit of their potential and with the growth of water demanded by the capital, future erratic inflow might lead to extreme water shortages. NamWater as well as the CoW identified the need to develop reliable additional water resources to secure the water supply situation.

4.5 Water demand in Windhoek

In 1991 the water consumption of the city rapidly approached the safe yield of the water resources available to the city (Burger, 2004)). Since the early 1990's chronic water shortages have been experienced from time to time. During the season of 1996/97 supply shortages became critical and various emergency strategies had to be implemented to save the situation. Burger (2004) states that these strategies included projects such as the abstraction of groundwater in the northern part of the country, additional boreholes in the Windhoek aquifer and a temporary emergency extension of the old Water Reclamation Plant. These strategies were launched to be able to supply the minimum amount of water needed by the city to function in the event that no inflow to the storage dams supplying the city occurred in a specific rainy season.

The historic and expected future water demand of Windhoek is indicated in Figure 12 below (See Appendix B for explicit values). Between the years 1967 to 1987 the water demand of the city doubled from approximately 6 million m^3 to 12 million m^3. From 1987 to 1994 the water demand rose by more or less another 6 million m^3. The ever-increasing demand and the panic during the drought of 1996/1997 made it abundantly clear that desperate measures needed to be taken in order to ensure sufficient water supply to the city.

Figure 12: Historic and forecasted Water Demand of Windhoek



Source: City of Windhoek, 2005

From the graph above it is evident that water demand in Windhoek fell dramatically after 1995. This was as a direct result of the Water Demand Management strategy that was developed and improved for implementation in 1994. Before this time there was what can be referred to as unrestricted water production and also unrestricted water use. From 1998 onwards, the past trend of increase in demand seemed to continue. This was in all probability caused by good rainy seasons coupled with restructuring within the municipality at that time. This restructuring led to the downsizing of the WDM section from a staff of two persons with input by the Head of the Water Services Department to a single person. This may have led to the stagnation of the WDM strategy implemented since this person also received a number of other operational responsibilities besides WDM.

The 15 years after 2004 shown in the figure are the forecasted water demand for the city. The demand curve is normalised to take the effect of temperature in account and assumes land development at a rate of increase of 10% more than the increase observed in period 1990 – 2000. This sharp increase in demand in the 1990's can mostly be ascribed to a drastic increase in the city's population due to the high rate of urbanisation that occurred after independence.

5. Water Supply Augmentation in Windhoek

5.1 Introduction

Since 1990 the City of Windhoek has launched specific initiatives to improve the supply of water to the city. These strategies were formulated and carefully planned with the realisation of the urgent need to develop additional water sources to secure the water supply situation and included the following:

- A dual pipe system for the irrigation of sport fields, parks and cemeteries was installed in 1993.

- Funding was obtained from the Kreditanstalt für Wiederaufbau (KfW) and the European Investment Bank for the construction of the New Goreangab Reclamation Plant (NGWRP) that was commissioned in July 2002.

- Pilot work to establish the technical viability of artificial recharge of the Windhoek Aquifer was carried out in the period 1996 to 1999. Phase 1 of the project is already completed with good progress being made with the implementation of phase 2.

5.2 The dual pipe system

Between 1990 and 1992 a dual pipe system was installed for the distribution of semi-purified sewage water to be used for the restricted irrigation of sports fields, parks and cemeteries within the city. The old Goreangab Water Reclamation Plant was integrated into the system in 2002 to supply a better quality of water for unrestricted irrigation through the dual pipe system. Approximately 1.44 Mm^3 was produced for irrigation in 2002 and the supply from this system is expected to increase to 1.78 Mm^3/a in ten years time (Burger, 2004). The rate of production of semi-purified water however, will depend entirely on the availability of purified effluent. The production of potable water from the NGWRP is currently limited due to a shortage of raw water for reclamation with irrigation water having a lower priority (Burger & Cronje, 2004). This irrigation water can be seen as a substitute for potable water as it does not impinge on the primary groundwater and surface water sources providing water to Windhoek (Cronje, 2004).

The dual pipe system is still limited in extent and plans exist to extend the system to provide more areas with semi-purified water that can be used for irrigation should there be a sufficiency in supply. This system is invaluable to the CoW as it takes huge pressures off the potable water supply during the summer months. The City of Windhoek is currently also working on the automation of the system in order to increase its efficiency.

5.3 The Goreangab Water Reclamation Plant

According to an interview with Cronje (2004), Windhoek's potable water supply up to 1968 consisted of borehole water and water from the Von Bach dam. Because of the erratic rainfall in the Windhoek region, the Von Bach dam could not be fully relied upon to provide enough water for the city and therefore the city desperately needed to look for an alternative water source. The construction of a water reclamation plant was at that time seen as the most economically viable option. The initial plant treated domestic sewage and the end product was good enough to be used for the irrigation of sport fields and green spaces. The plant was gradually upgraded as technology caught up and eventually produced water of a high enough quality to supplement the potable water supply to Windhoek. Originally a mixture of treated domestic sewage was blended with water from the Goreangab dam as main supply to the process. However, the quality of the water from the Goreangab dam deteriorated to such an extent over the last couple of years (Cronje, 2004) that an upgrade of the plant was needed in order to still use its water for the process. The objective of the new plant was to reduce the portion of the water used from the dam, while increasing that of the secondary effluent from the Gammams Waste Water Treatment Plant (GWWTP). In the end, the new plant will improve water security of the Windhoek supply system with less reliance on precipitation.

Figure. 13 and 14: The New Goreangab Water Reclamation Plant just outside Windhoek

The New Goreangab Water Reclamation Plant (Figure. 13 and 14) was completed in July 2002 with a design capacity of 21 000 m³/day which translates into a maximum flow rate of 875 m³/h (Windhoek bulk water master plan 2004:26). The plant treats secondary effluent from the Gammams Water Care Works blended with water from the Goreangab dam in a sophisticated process which makes the water safe for domestic use. Apart from an essential improvement in the quality of life of Windhoek's population, the plant represents an integral part of protection measures for local water resources.

The reclamation of domestic sewage for drinking water is generally not accepted by the public and psychological barriers normally have to be broken down first. In the case of Windhoek however there is really no other cost-effective alternative. The residents of Windhoek have actually taken pride in the fact that they are the only ones in the world that make use of recycled potable water. The insurance given by the City Council to its residents is that the treatment of this water uses a so-called 'multi-barrier' process ensuring the production of high-quality drinking water. According to Vatech (2004a), there are no health risks associated with the consumption of the potable water produced by the treatment plant as it is of outstanding quality. Despite early preconceptions about the process, the city has been reclaiming water for potable use in this way for more than 30 years and to date there has been no evidence that this water is in any way harmful to the city's residents. Most people will certainly be censorious about the reclamation of domestic sewage into potable water, but the residents of Windhoek has shown that when there is no other alternative even those barriers can be broken down.

5.4 Recharging the Windhoek Aquifer

The city of Windhoek is located within the greater Windhoek basin surrounded by mountain ranges to the west, south and east. A river valley forms a gateway towards the north. Three main catchment areas exist within the basin. These are the Klein Windhoek River with tributaries, the Gammams River and the Aretaregas River catchments.

The Windhoek aquifer is located within the Windhoek basin consisting out of three geological environments. The hydrogeology of the area is dominated by the quartzite and schist horizons and the extensive system of faults and fractures that is prevalent throughout the Windhoek aquifer. The mechanism of natural recharge to the Windhoek aquifer has to date not been studied in sufficient detail to be acquainted with the exact details thereof. Recharge to fractured aquifers, such as the Windhoek aquifer, commonly takes place by infiltration into exposed fractures in outcropping areas, or areas where there is limited soil cover. According to Van der Merwe (2005), effective recharge usually only occurs after a minimum threshold of rainfall has occurred, which in the case of Windhoek, will only be after summer rainfall events. This minimum threshold value in Windhoek is currently unknown.

The Windhoek aquifer's sustainable yield has been estimated to be 1.93 Mm^3/a. Considering that an average abstraction of 2.1 Mm^3 over the years has resulted in a steady decline in groundwater levels in most areas, it seems that 1.93 Mm^3/a may be in excess of the aquifer's sustainable yield. It has been estimated by the City of Windhoek that the natural recharge of the Windhoek aquifer is approximately 1.73 Mm^3/a. This means that the aquifer has been over-utilised over the past fifty years. If the aquifer is therefore used at the current average abstraction rate with no artificial recharge, it will continue its steady decline.

When the aquifer recharge project is fully implemented in 2018 it will not increase the sustainable water supply from the Windhoek aquifer as there will be no change to the natural recharge. However, as De Waal (Interview, 2004) stated during his interview it will have the following important benefits:

- It will reduce the evaporation losses by banking water underground in years when there is surplus run off into the surface storage dams which would otherwise have evaporated. This would effectively increase the total yield of the dams.

- It is estimated that with the use of deep wells (400 – 500m depth) in the Windhoek aquifer there will be a "bank" of at least 100Mm^3 available for abstraction. This water can be abstracted in years of shortage when the surface dams have reached their maximum abstraction levels. This so-called "bank" can then be topped up again in years of abundance.

- Having a large "bank" of water available at the point of consumption makes it possible to provide the peak demand from the aquifer. The aquifer can then be replenished in the off-peak months. The large capacity bulk supply schemes of NamWater, which traverse hundreds of kilometres, will then not have to be designed to supply the peak demand, only the average demand effecting a substantial cost saving.

The water available for the artificial recharge can be regarded as the difference between the quantity available from the sources and the expected water demand.

Due to the variable inflow in the surface reservoirs this quantity will vary from year to year. According to De Waal (2004), the system can be optimised so that less water can be recharged during the peak months of the year and more water during the off-peak months.

The artificial recharge project is divided into four phases with phase 1 already completed. The total capital cost for all four phases amounts to N$ 165 671 803 (De Waal, 2005). This estimation includes the development cost of new infrastructure needed. De Waal (2005) stated: "Although this may sound like a huge amount of money, it is by far the cheapest option to augment supply to the city".

Phase 1 included a pilot study and the drilling of 5 boreholes to act as injection/abstraction systems. These boreholes created an artificial injection capacity of 3.17 Mm^3/annum. The City of Windhoek is currently busy with phase two. For abstraction purposes, this phase includes the upgrading of existing boreholes, drilling of 6 new deep (400m) abstraction and injection boreholes, the upgrading of existing pipeline infrastructure and the construction of new pipeline infrastructure. For recharge purposes this phase includes using the boreholes for both injection and abstraction, construction of a new pump station for the bulk supply system and the provision and construction of booster pumps to pump water to the boreholes.

Phase three is expected to be completed by 2010 and include the drilling of 7 new deep (400m) boreholes, upgrading of existing pipeline infrastructure, addition of more booster pumps and the construction of extra pipelines for injection.

Phase four includes the further upgrading of selected existing boreholes with new pumps, linking boreholes to the network with new infrastructure, drilling two new deep boreholes and using these two for injection and abstraction. This phase is planned to start in 2017 and will be completed in 2018.

5.4.1 Vulnerability of the aquifer

Owing to the strategic nature of the Windhoek aquifer as a key water resource for Windhoek, it is imperative that it be protected against pollutants. Recharge of the Windhoek aquifer significantly increases useful storage capacity and, as a result, the fluctuation in the water table also sees greater variation. With the artificial recharge, groundwater levels are raised considerably, and this makes the aquifer even more vulnerable to contamination. Research has shown that the Windhoek aquifer is especially vulnerable along the quartzites in the Auas Mountains and along the foothills of the mountains, which lies on the Southern edge of the Windhoek basin. With the exposed fractures and very little topsoil cover in these areas, major pollution may spread within a very short period of time (days) provided that it is combined with a gradient and hydraulic flow. It is very high priority of the City of Windhoek to protect these aquifers from any contamination and already desperate measures have been taken by them to do so.

In the event of contamination of groundwater, remediation of fractured aquifers can sometimes be feasible, but this entails a complex process creating temporary impermeable interfaces through the injection into the high transmissivity areas around the pollutant contamination (De Waal, 2004). Due to the cost and complexity of this process, many water retailers would simply turn to an alternate source for their supply. The City of Windhoek however, may not have this luxury and will most probably be faced with the expensive task of cleaning up.

According to De Waal, (2004), all future development areas south of the existing development in 2004 were identified by the CoW as areas with a high to very high pollution potential. These areas were classified by the City of Windhoek as a 'no development zone' in order to protect the groundwater from potentially being polluted. Various other already developed zones have also been identified and development in these zones are limited. These zones can clearly be seen in Appendices C and D. In Appendix C the so-called 'no development zone' is indicated by the red line as shown on the map, while the yellow line shows the restricted areas which unfortunately have already been developed. The red circles on the map show particular vulnerable zones. The City of Windhoek also had no other choice but to force the movement of some industries with a high pollutant potential in this area to other areas in the city.

5.4.2 Benefits and risks of developing the Windhoek aquifer

The City of Windhoek decided to go ahead with the development of artificial recharge of the Windhoek aquifer. Although there are certain risks involved, water planners stated that Windhoek and the country as a whole could not afford not to implement the project.

The benefits and risks of developing the Windhoek Aquifer are summarised below.

Benefits of developing the Windhoek Aquifer:

- It would increase security of supply in the central area.

- It would reduce the cost of developing additional capacity in the NamWater supply infrastructure.
- It would reduce the operating cost of supplying the peak demands of Windhoek over long supply lines.
- The development of the Windhoek aquifer would allow better phasing of the project and different project phases could be introduced as dictated by the actual demand. All the other options would have to be constructed to their full capacity at the commencement of the project.
- Deep well drilling in the Windhoek aquifer would increase the size of the water bank and improve the flexibility of the system as well as the supply security.
- The project would improve the efficiency of the entire NamWater supply system to the central area.
- There is a lower risk of water shortages due to repair and maintenance over the present long distance transfer schemes. Water could be abstracted from the aquifer at short notice, as there would be a large bank sitting directly beneath the city.
- Large investments to increase the capacity of the Von Bach to Windhoek pipeline could be postponed.
- The environmental impact of the project would be low.

Risks involved in developing the Windhoek Aquifer:

- As mentioned, the Windhoek Aquifer has a high risk of pollution due to its location and the geological structure of the area.
- The introduction of the project would lead to higher water tariffs since the investment cannot be recovered through additional water sales.
- The quality of the water injected into the aquifer would be a crucial aspect of the project.

From the above-mentioned benefit and risk analysis, one can understand why the City of Windhoek decided to go ahead with the project. Added to the benefits mentioned, the high financial cost involved in implementing and developing the project is relatively low when compared with the financial cost of other alternatives.

6. Water Demand Management

6.1 Introduction

Water demand management is another way of looking at water resources management, away from traditional supply development to an improvement in efficiency of use, conservation, recycling and reuse of water. Demand management looks at altering demand and the way water is used in order to achieve more efficient and cost-effective water use. It helps to reduce wasteful use of the resource, which represents an opportunity lost as well as the use of water without an economic purpose. Water demand management can sometimes prevent the need for physical or infrastructure investments, providing real efficiency gains to society (Magnusson, 2005:23).

Windhoek has a high population growth rate and is very important as economic centre. Taking the environmental aspects into account, high capital investment is needed to make more water available to the central area. Water demand management is thus the only viable option to use existing resources more efficiently. Furthermore the bulk of the growth in Namibia is concentrated in the central area where all easily accessible water sources have already been tapped.

Well planned and implemented water demand management measures can reduce a water authority's cost significantly through avoiding or deferring the need for new capital works and also by reducing operating costs associated with pumping and water treatment. However, it should be taken into consideration that the reduction in demand from the consumer means that less water is sold. This in turn results in a reduced income generated by the water authorities. The main purpose of water demand management however is to enhance the efficient use of water. Esterhuizen (Interview, 2004) explains that WDM entails a reduction of the water used to perform a particular task without sacrificing the level of customer service. For example, the use of a low flush toilet and an efficient showerhead does not influence the level of service to the user.

The fact that water is such a scarce commodity and because the demand for water is always growing, the City of Windhoek has in the past implemented a number of WDM measures. This was done in order to reduce the demand and thus also limit the extent to which water abstraction from conventional sources such as dams and boreholes was needed. At present a number of those WDM measures are still in place, with some success.

6.2 Water Demand Management in Windhoek

According to Esterhuizen (2004), water demand principles have been implemented in Windhoek on an ad hoc basis since 1992. An integrated water demand management policy was developed during the first half of 1994 and approved by the City Council of Windhoek in July 1994. Since then the policy has been further refined and more attention has been given to the implementation thereof. Esterhuizen also (2004) states that a wide range of water demand management measures have been classified in Windhoek as issues involving policy, legislation, technical issues as well as public education and awareness.

- *Policy Matters*: The policies that were approved and implemented in Windhoek include the implementation of a permanent rising block tariff system that reflects the incremental cost of water with increased consumption. This has proven to be successful in changing the water use habits of consumers. Other complementary policies include smaller residential plot sizes in new developments in Windhoek and higher densities (two houses per plot) are allowed in existing urban areas. In practice it reallocates water from garden use to indoor use. In older parts of the city rezoning of low-density residential plots to businesses and town houses is allowed. The principle of maximum reuse of water was also accepted by the City Council in 1994 (Windhoek bulk water master plan 2004:35).

- *Legislation*: Since existing legislation have become outdated, new Water Supply Regulations were promulgated in 1996 to address the conservation of water in Windhoek. If wastage of water on a private property occurs, it can be addressed immediately in terms of the new regulations. The regulations prescribe the use of water efficient fittings and make provision for retrofitting if and where inefficient fittings are being used. During summer and periods of high evaporation, no watering of gardens during certain times of the day is allowed and swimming pools must be covered in periods of no use.

  Regular testing of underground fuel tanks is mandatory and all tanks have to be registered. Groundwater abstraction from private boreholes can also be controlled according to the Water Regulations.

- *Public campaigns*: Strong emphasis was placed on customer advice, public participation and distribution of pamphlets on the efficient use of water. Water audits are offered free of charge to larger commercial, industrial and government departments.

- *Technical measures*: The technical measures that have been approved and implemented in Windhoek, include:

    - Operation for maximum efficiency in order to lower non-revenue water,
    - Lowering of municipalities own water consumption, and
    - Practical advice to consumers to curb losses of water.

A programme to train community based plumbers and the training of gardeners on efficient garden watering was also identified as an important issue that should be addressed. In a survey done of selected households (see Windhoek bulk water master plan, 2004:36) it was found that some gardens received up to five times the quantity of water needed for the plants.

6.3 Evaluation on the implementation of WDM

In order to ensure efficiency of a Water Demand Management strategy, the success of the measures needs to be assessed from time to time. An assessment was made by the author by investigating the situation and comparing the different measures proposed with what has actually been implemented and to what degree of success. Each demand side measure has been evaluated separately and a summary of the evaluation can be seen below.

Policy Issues:	**Reason:**	**Status as of August 2005**
1. Raising block tariff system	To curb excessive water use and reflect the real cost of supply	Well implemented
2. Maximum re-use of water	Semi-purified water for irrigation purposes	Well implemented
3. Reduction of municipal water use	Reduce water consumption on Municipal gardens by 50%	Pursued from 1995 and to 1997, nothing done at the moment.
4. Smaller plot sizes and higher densities in all existing developed areas	Plot sizes in new development are reduced	Done in new townships from 1994, and since 1990 two houses/plot on all existing plots has been allowed.
5. Implementation of urbanisation guidelines		Provide services for different levels of development for all services including water since 1992.
6. Guidelines on wet industries	Stop development of new wet industries	No wet industries may develop. Policy prohibits development of new wet industries.

Legislation:

1. Prevention of undue water consumption on private properties	Water control officers needed to address wastage of water on private properties	These four were controlled by the water control officer and meter readers from 1995 to 1997. Done very leniently since.
2. Use of water efficient equipment	Compulsory in new developments: metering of taps, low flow showers, dual flush toilets	
3. Garden watering	Only done after 16:00 or before 10:00	
4. Swimming pools	Must be covered when not in use	
5. Groundwater	Groundwater abstraction from private boreholes and groundwater levels to be controlled	Never implemented
6. Pollution	Prevention of water pollution above and underground	Started only in 2004.

Technical measures:

1. Lowering of un-accounted for water	Leakage detection, repair programs, water audits, proper management of meters and systematic pipeline replacement	Increased since 1997. Big campaign launched to lower un-accounted for water in 2005.
2. Efficient watering of gardens	Advice on proper irrigation systems for gardens	Only advocated from 1995 – 1997, nurseries now try to drive it.
3. Artificial recharge	Artificial recharge of the Windhoek aquifer	Pilot work done in 1997/1998, first phase implemented in 2003
4. Rainwater Harvesting	Catching and storing rainwater	No progress, costs of reservoirs to expensive for the consumer.

Public Campaign:

1. Educational Programmes	Lectures in schools, information on radio and television, advertisements in newspapers and pamphlets distributed with bills.	Done from 1995 to 1997, with low profile since then. Some campaigns are currently run to lower water consumption in schools.
2. Consumer advisory services	Advice on detecting water losses and how to detect leaks	Done from 1995 to 1997. Now only done on ad hoc basis.
3. a. Advice on water efficient gardening methods b. Training gardeners	Advice on water wise gardening	a. Implemented b. Not successful
4. Community	Empowerment in formerly neglected areas	Public campaigning worked rather well, but training and further use of community based plumbers was not successful

Table 3: WDM Principles implemented in Windhoek from 1992 – 1998

It has been established that most of the *policies* were indeed implemented successfully. In 2001 the City Council was forced by the Government to change their policy to allow wet industries in the city. Since then the City of Windhoek has managed to again change the policy to not allowing the further development of any wet industries in the city. Block tariff systems were implemented successfully as summarised in the table below. This is a very effective means of targeting higher consumers of water and a very important instrument to manage water use efficiency because residential consumers use from 65% to 75% of the total consumption in most urban areas. Water planners in Windhoek see this as the most effective tool to curb water demand and during my interviews this was an issue that came up repeatedly. A summary of the latest tariffs is presented in Table 4 below. This is the normal tariff, but the City of Windhoek recently introduced a strategy of using another block tariff system during months of short supply. This will effectively mean that the size of the consumption blocks will decrease and that water will become more expensive in dry periods.

Table 4: Summary of Tariffs Charged for Residential Consumers

Meter Size	Basic Monthly Tariff (N$)	Consumption Blocks (m^3/month)	Tariff (N$/$m^3$)
15 mm	11.62	0-6	4.17
20 mm	27.28	6-36	6.94
		36+	12.78

Source: Compiled by the researcher based on data from the City of Windhoek, 2005

The implementation of *technical measures* was not as successful as it could have been. Except for low flow showers, the non-availability of good quality products in Namibia jeopardizes the implementation of retrofitting and installation of water efficient toilets and showers in buildings (Esterhuizen, 2004). With the implementation of the new Water Act in South Africa however, more good quality water efficient products should become available in the near future. Un-accounted for water is still a big problem in the city. With a recent project that was done by the polytechnic of Namibia (see Windhoek bulk water master plan 2004:36) it was found that leakage rates in some households are very high due to inferior equipment and lack of maintenance. The leakage on premises varies from 31 to 110 litre/erf/day with an average of 87.8 litre/erf/day. A realistic leakage figure should be in the order of 20 litre/household/day. If this can be achieved, the estimated savings that can be realised amount to N$ 5.8 million per annum, calculated at an average selling price of N$ 6.00/m^3 (Windhoek bulk water master plan 2004:36). The City of Windhoek however, is busy with a project to detect water leakage. Different zones are identified where the comparison is made between total water metered in the zone and actual water sold through individual household metres. This then gives an indication of how much water is lost between the bulk water meter and that of the consumer. Advising the public on water efficient gardening methods is a campaign now driven by nurseries. Nurseries in the city have agreed to try and change gardening habits of residents to among other things, plant vegetation not as dependent on water. The programme to teach community based plumbers also did not work as envisaged. The idea was to take people from communities in especially low-income areas an train them as plumbers so that they can go from house to house and do plumbing related jobs for a small amount of money. This project however got off the ground by training the plumbers, but as soon as they were trained, they joined existing plumping services in the city and now work as formally employed plumbers.

Legislative measures are not being well monitored at the moment. According to Esterhuizen (2005), watering of gardens during periods of high evaporation and covering of swimming pools are only enforced during periods of water shortages, while the intention of the legislator was to change habits and improve long-term water use efficiency. He also did not see the need to enforce this legislation in times where sufficient water was available. The follow-up on underground fuel tanks is not done in accordance with the legislation. As explained earlier, this could lead to disastrous groundwater pollution. It is however important to realise that in practice it is a problem to implement and control these regulations. Consideration should however be given to revisiting some of these regulations to improve the practical implication or to investigate alternative incentives for compliance.

The main objective of the *public campaigns* that were launched at various times was to sensitise the public to water use efficiency (Esterhuizen, 2004). Since 1997 no public campaigns or water audits to larger consumers have been done. If the water consumption of the larger consumers is analysed, there is a clear trend of growing water demand that may not be related to increased production. Since there is no accountability of Government Departments, large percentages of water use are linked to wastage of water due to poor maintenance on plumbing systems. The City of Windhoek has recently started with a campaign to decrease water consumption in government schools.

Despite some shortcomings in the implementation of Water Demand Management, the initiative substantially reduced consumption in Windhoek and shows huge potential. In the Central Area Systems Update (2001) the reduced water consumption was attributed to the following factors:

- Most of the new residential development has taken place in the middle to low-income sectors of the community. These sectors of the community use less water than the middle and high-income sectors.

- Even in the middle and middle to high-income sectors, the new developments have smaller plot sizes, resulting in smaller gardens and therefore less water consumption.

After the 1995/96 drought, Windhoek residents generally reduced the size of their gardens, and changed the garden types, layout and irrigation methods, all of which combine to reduce water consumption (Esterhuizen, 2004). Also, new appliances such as washing machines, dishwashers, toilet cisterns and showerheads became more water efficient.

It was also determined (see Windhoek bulk water master plan 2004:43) that in new developments the water consumption rates are lower for similar sized erven than in the rest of the city. This is as a direct result of the City of Windhoek's Water Demand Management policy of developing smaller erven, even for higher income groups. This can clearly be seen in Table 5 below. The newly developed suburb, Kleine Kuppe (marked in green), could be classified as a high-income area, but still the daily average consumption of water is much lower than the other high-income suburbs. Smaller erven force residents to have smaller gardens, and as a result the water consumption per property is lower.

Table 5: Daily Average water consumption per erf

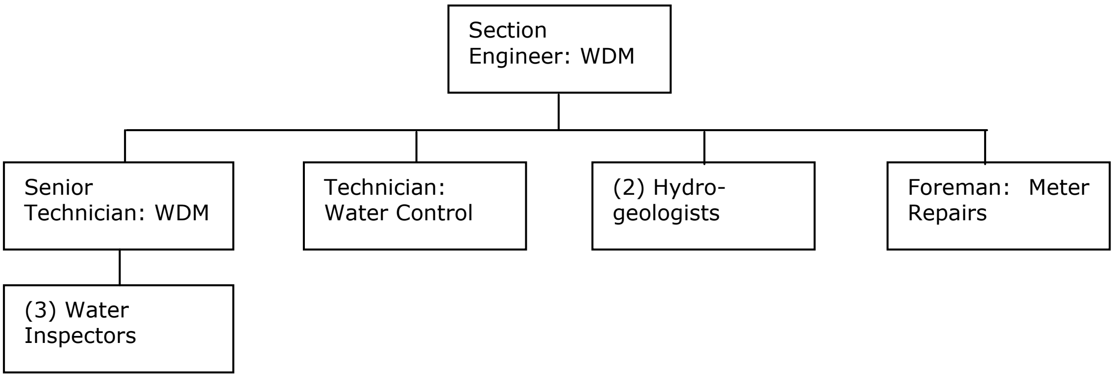
	2002		2003/2004		Daily Average of Income Group	
Suburb	No. of Water Meters(Sample)	Daily Average	No. of Water Meters(Sample)	Daily Average	2002	2003/4
Academia	593	1.14	611	1.17	High Income	
Ausblick	57	1.17	33	1.06		
Eros Park	582	1.38	580	1.56		
Hochland Park	1364	1.06	1354	1.05		
Klein Windhoek	2838	1.22	2698	1.28	1.13	1.16
Kleine Kuppe	673	0.61	509	0.68		
Olympia	943	1.29	914	1.24		
Pioneers Park	1779	1.13	1767	1.21		
Cimbebasia	639	0.53	534	0.62	Middle Income	
Dorado Park	1071	0.61	1003	0.66		
Khomasdal	4610	0.63	4607	0.69	0.54	0.60
Otjimuise	939	0.43	799	0.47		
Rocky Crest	466	0.49	397	0.55		
Goreangab	1766	0.27	1322	0.32	Low Income	
Hakahana	902	0.36	859	0.39		
Katutura	8600	0.43	8375	0.45	0.47	0.45
Okuryangawa	2489	0.41	2320	0.49		
Wanaheda	2467	0.59	2432	0.60		
	32778	0.76	31114	0.81		

Source: Compiled by the researcher based on data from Steynberg, 2005

6.4 Future prospects of WDM in Windhoek

As mentioned in chapter 4, the Water Demand Management Division of the City of Windhoek was reduced to only one person in 1998. The City of Windhoek however is busy constructing a whole new division with a new approach to Water Demand Management. According to Esterhuizen (2005), this new approach includes the principles of Integrated Water Resource Management and will not only focus on WDM alone. Mr Esterhuizen was appointed as section engineer of the Water Demand Management division in July 2004 and they are busy restructuring the whole division. The restructuring is still in progress and most of the positions in this new division have been filled. The new structure includes the following positions:

Table 6: New Structure in WDM division in CoW



Source: Compiled by the researcher based on data from the City of Windhoek, 2005

The responsibilities of each position is summarised in table 7 below.

Table 7: Responsibilities of WDM division in the CoW

Section Engineer: WDM	• Management
Senior Technician	• Meter Readings • WDM • Supervise Inspectors
Technician: Water Control	• Optimisation of Water System • Quantity and Quality regulation • Prepaid Systems • WDM
Hydro-geologists	• Aquifer management
Foreman: Meter Repairs	• Repairing and checking water meters
Water Inspectors	• Meter reading • Policing illegal connections • WDM issues

Source: Compiled by the researcher based on data from the City of Windhoek, 2005

The first issue the new WDM division of the City of Windhoek would like to address is the reduction of 'non-revenue' water. The diagram below represents the International Water Association water balance and clearly shows what is meant by non-revenue water. Mr Esterhuizen (2005) stated: "The key is to first identify where the problem is and where most water is lost." According to him, big emphasis will also be placed on water lost beyond the consumer's meter. The owner will be held responsible to repair and reduce water leakage if it occurs on his/her side of the meter. The City of Windhoek will however give assistance and advice in this regard. Apparently the biggest problem exists at governmental organisations and this is one area that desperately needs attention. The main problem at government organisations is broken pipes and the careless use of water. Mr Esterhuizen said: "People at these places waste water, because they know the government pay the bills". Schools seem to be the biggest culprit and the City of Windhoek recently launched a campaign to reduce water losses at government schools. This is done in conjunction with a local commercial bank Windhoek who will award a prize to the school that manages to save the most water over a certain period.

Table 8: Standard International Water Association Balance

<table>
<tr><td rowspan="9">System Input Volume</td><td rowspan="4">Authorised Consumption</td><td rowspan="2">Billed Authorised Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="7">Non Revenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Losses</td><td>Unauthorised Consumption</td></tr>
<tr><td>Customer Meter Inaccuracies</td></tr>
<tr><td rowspan="3">Real losses</td><td>Leakage on transmission and distribution mains</td></tr>
<tr><td>Leakage on overflows at storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to point of Customer Meter</td></tr>
</table>

Source: City of Windhoek, 2005

The new approach as explained by Mr Esterhuizen also includes the improvement of the accuracy of the meter readings received by the CoW. He believes that they cannot make assumptions and address issues if they are not sure about the accuracy of the information. This will be done through Water Inspectors who will take regular actual meter readings with less reliance on estimations. These people will also be responsible to look for and report illegal connections. The City of Windhoek recently also started with a replacement program, which includes the replacement of inaccurate meters or meters where losses occur. This project only started in the beginning of 2005 and is a long-term strategy. Each neighbourhood will be dealt with individually one after the other. One of the oldest neighbourhoods in Windhoek namely Khomasdal, where Mr Esterhuizen believes up to 50% losses occur, was chosen as the first to be dealt with. He also stated that the return on investments for this project would break even within less than a year. The criteria used to replace the meters are listed below:

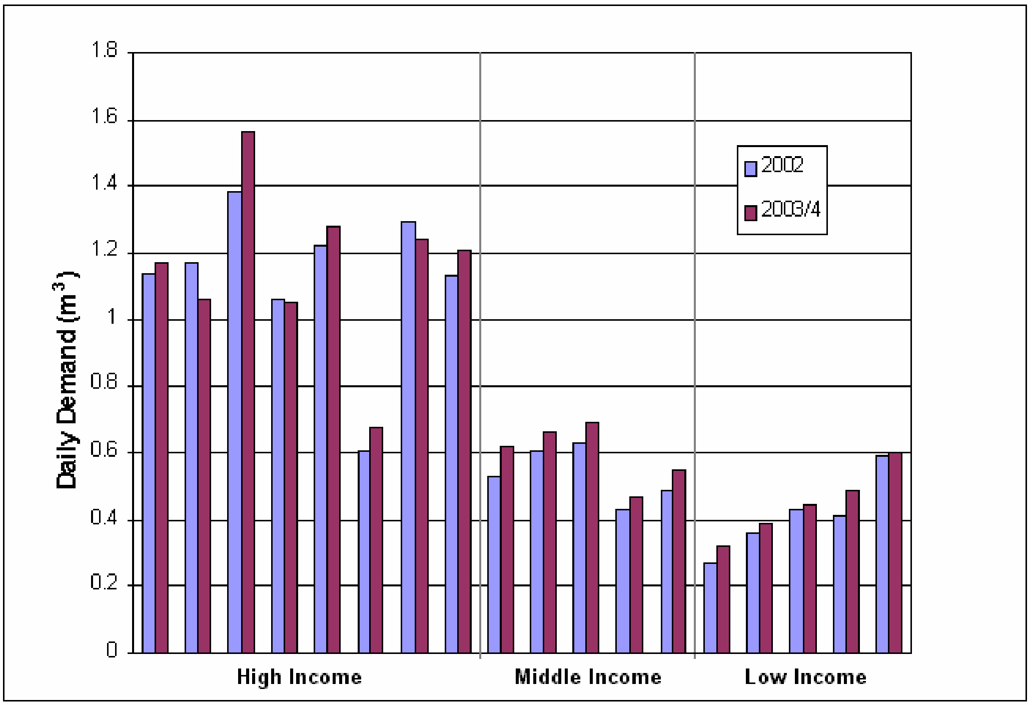
- Inaccuracy of more or less 4%
- Meters with readings of more than 3000 m^3

- Meters that are stuck
- Meters that are unreadable

The WDM division also would like in future to target residential consumers who consume a lot of water. These people can be identified from meter readings and if they consume more than 50 m³ a month, they will be approached. Sending personal letters to these people is a communicative tool that appears to work well. For example, Mr Steynberg (Interview, 2005) sent 3000 letters in 2004 to those whose consumption was more than 50 m³/month. There was a great response from these people as most did not realise they were consuming so much. This is mainly because they have a large enough income not to worry about an increase, and thus paid their bills without even looking at them. In the letters it had been stated that if they didn't lower their consumption then their supply would be restricted.

This high consumption of water in higher income neighbourhoods can clearly be seen in Figure 15 below. The higher income suburbs use significantly more water on average per day than the middle and lower income suburbs. Apart from the negligence of the high-income consumer, this trend can also be related to the fact that the higher income areas have bigger plot sizes and as a result bigger gardens. Households in these areas are also more inclined to have swimming pools on their plots.

Figure 15: Daily average water consumption according to Income Groups



Source: Compiled by the researcher based on data from Steynberg, 2005

The City of Windhoek is trying to keep pace in service provision with urban growth even though it is associated with high costs. In low-income informal settlements the City of Windhoek strives to provide water in the form of a communal water point no further than a walking distance of 200m. This is as specified by the National Housing Policy and is part of the City of Windhoek's development and upgrading strategy. All of these water points are connected to a water meter and some are installed with an electronic prepaid system. In these cases the user has an electronic card, which is used to access the water already paid for by him/her. This is done to ensure that the water used is paid for. It also seems to be better understood by people living in these areas as they struggle to understand the concept of paying for something that has already been used. It is also important to note that only 45% of all water used in Windhoek is consumed by low-income households, even though this group makes up close to 70% of the city's population. This group is also undoubtedly the fastest growing population group within the city (Van der Merwe, 2005).

Figure 16. and 17: A Communal and prepaid water point in an informal settlement in Windhoek

6.5 Possibilities for WDM

There are a number of strengths, weaknesses, threats and opportunities that the WDM division in Windhoek comes across when considering the implementation of water demand management measures in the city.

Table 9: SWOT Analysis of WDM in Windhoek

Strengths
• Has past experience in water demand management • Has a number of successes in reducing water demand
Weaknesses
• New structure in department
Opportunities
• Can learn from past experiences • Utilise the knowledge of the many water experts in Windhoek
Threats
• Perception of the public that water should be free • Lack of knowledge of water situation within the CoW and central government • Hindrance from other sectors since water is not very high on their priority lists

Source: Compiled by the researcher

Strengths

As mentioned previously Windhoek has a history of the application of WDM with its residents very familiar with water demand management measures. Even though not all measures were equally successful, many lessons can be learned from past failures and successes.

For example, involvement of the City of Windhoek in reducing water demand by schools and government buildings in 1996 (by handing out washers and by supplying information on acceptable water use) led to a 50% decrease in water used by these buildings. This can be an example of a measure that was successful, but needs prolonged attention to remain successful.

Weaknesses

No real weaknesses could be identified within this division except for the fact that this division of the City of Windhoek is relatively new in the sense that restructuring took place and not a lot of experience could be relied upon in the division. This however could also be regarded as a strength as the new structure and young blood can bring about fresh ideas and a fair amount of enthusiasm.

Opportunities

As mentioned, the CoW has the advantage of being able to learn from its past actions and successes concerning water demand management. A great opportunity lies within the city and its people. The city has quite a number of experts on water supply and demand management who are not only very knowledgeable in the field, but also has great previous experience.

This type of knowledge could and should be utilised by the City of Windhoek. It does not mean that outside assistance should not be asked for, but one should realise that sometimes people from outside the city are not fully aware of the local conditions and may not realise the full impact of measures taken due to a lack of knowledge about past successes and failures.

Threats

The City of Windhoek could pay more attention to water demand management in times of no water shortages. However, the question should be asked as to what extend WDM should be actively pursued during those times? According to a study done by Poolman (2004:30), residents in Windhoek become 'immune' to information about water saving if they are bombarded with the information continuously. The block tariff system however, has been successful to reduce water consumption and to keep people aware of their consumption during all periods.

Another problem that exists within Windhoek is the fact that many residents have the perception that water should be free (Magnussson, 2005:8). A big challenge therefore exists to change the attitudes of people to perceive water as a public service that needs to be paid for.

Furthermore, not only the perception of the public needs to be addressed, but also that of other sectors within the City of Windhoek as well as the central government. Poolman (2004:31) found in her study that in some cases members of the City of Windhoek and of the central government are not fully aware of the delicate water situation surrounding Windhoek. Statements about water are therefore made which totally contradict what is being said about water being a scarce resource. As a result, such statements pose a threat to the work that has been done, and it takes a long time to convince the public otherwise. The reasons for such faulty statements according to Poolman (2004:31) is most likely because the members have not received accurate information concerning the water system and are left to draw on their own (sometimes inaccurate) conclusions. Attention must be paid to change the perceptions at the governing level otherwise it will become very difficult to change the perceptions of the public.

7. Alternative Supply Augmentation Possibilities

7.1 Desalination Plant

Because of the fact that Windhoek is not situated near permanent water bodies, the city already has made use of the most efficient and economically viable options in and around the city. There are only a few other strategies that can be considered. One of these includes the building of a seawater desalination plant. According to Cronje, (2004) the building of a desalination plant with the same capacity as the New Goreangab Water Reclamation Plant would have cost a great deal more. The cost of the plant was estimated at round about N$ 5 billion. This cost estimation included the cost of desalination, high pressure pipelines, pumping stations and connection to the NamPower Grid. The associated environmental problems that go along with the construction of the plant made it an option too costly to consider.

7.2 Emergency water from Okavango River

An option that was given serious consideration was the construction of a 700km long pipeline connecting Windhoek to the Okavango River. The Okavango River forms the North Eastern border of Namibia and is a perennial river that originates in the Angolan highlands and flows along the border of Namibia through the Caprivi region and into Botswana. The Eastern National Water Carrier is a pipeline that already exists and supplies a large part of Namibia with water. The pipeline runs from Berg Aukas mine to Grootfontein and through the Northern part of Namibia, until it connects with the Von Bach dam (De Waal 2004). The only missing part to connect the pipeline with the Okavango River is some 250km from Grootfontein to Rundu, which is situated on the banks of the Okavango River.

However further extension of the Eastern National Water Carrier to the Okavango River will be subject to the approval of the governments of Botswana and Angola. The Okavango River provides water to the internationally known Okavango wetlands, home to mammals, birds, fish and other animals, situated in Botswana. The Delta is a key feature of the regional tourism market and provides thousands

of jobs, which contribute to the generation of US$250 million in revenue for Botswana each year (Maletsky, 1999). Consequently the required environmental impact studies and the negotiation of an acceptable agreement to abstract some water from the Okavango River for the central area of Namibia will take time.
As a matter of fact the Okavango River and Delta has been threatened for a few years by the proposed pipeline that would divert water from the river to Windhoek. A report by International Rivers Network and Conservation International (see Rothert, 1999:1), based on data gathered by the water department and other agencies in Namibia reveal that the pipeline is not as practical as a combination of the less expensive, more sustainable measures, which could meet growing demand and sustain the country through a future drought.

Because of a drought in the 1996/1997 rainy seasons, the government instructed that the design of the pipeline that would pump water from the Okavango River to existing water supply canals be commenced. Good rains came however, and the plans were temporarily abandoned. When the drought appeared in 1999/2000 and again in 2002/2003 the fate of the Okavango River was in the hands of officials and water planners. According to Pottinger (1997), researchers who have studied the Okavango Delta feared the pipeline's diversions could harm the rich wetlands fed by the Okavango seasonal floods, and the communities and wildlife that thrive on this unique ecosystem.

During the 1999/2000 rainy seasons, when drought again hit the country, Rothert (1999:2) stated that water planners estimated the central area supply would fall short by 18 million cubic meters when the reservoirs ran dry. This is exactly the volume of water the government planned to extract from the Okavango through the pipeline before the good rains came and the plan was again abandoned.

Today the potential supply deficit is significantly reduced due to the various other strategies implemented by the City of Windhoek as described in this study. Rothert (1999:3) states that the average cost of water produced by the alternatives described is less than half the cost of Okavango water, and many of them could be implemented more quickly than the two-year construction time on the Okavango pipeline.

By using the option of storing water underground, it is argued (Rothert 1999:3) that as much as 8 million cubic meters per year could be saved, which is almost half of Windhoek's annual demand, at approximately one fourth the cost of piping water from the Okavango. By implementing water demand management in all towns in the central area, it is estimated that a further four million cubic meters can be saved, at less than one-fifth the cost of water from the Okavango River.

7.3 Additional options

There are other possibilities, which can also reduce the possible supply shortfall. These possibilities include abstraction of water from mines north of Windhoek, which has recently closed down, and the abstraction of water from a complex of aquifers that have not been significantly tapped to date. NamWater believes these mines could serve as long-term sources for the central area and during emergencies produce about 15 million cubic meters per year for two years. The Department of Water Affairs also believes that the aquifers could yield as much as 15 million cubic meters per year on a sustainable basis, and another 10 million during droughts. It is important however that these aquifers be protected and only be used in cases of emergency. They should not be exploited for a period of more than two years consecutively.

8. Analysis and Recommendations

Policy makers and water managers in fast growing cities in water scarce regions are faced with the dilemma of meeting an increased demand for water for maintaining socio-economic development, while at the same time striving to curb excessive demand. These are two conflicting, but equally important objectives. Cities cannot rely totally on technical supply solutions, but the relevance of these measures cannot be ignored either. Supply side management combined with water use efficiency is crucial. WDM is one very important instrument to achieve urban water security.

In this paper, I looked at different supply side measures in the city of Windhoek. The recharge of the Windhoek aquifer stood out as the most efficient and cost effective strategy implemented by the City of Windhoek. The implementation of this strategy however is still in its early phases and a lot still needs to happen before it is fully operational and can be used to its fullest potential. During my interviews it became clear that the most important objective for water planners in the city is to ensure water security in the long run. According to my analysis the most effective means of doing this is to use WDM as a strategy to curb demand while increasing supply with aquifer recharge. This strategy correlates very closely with the objectives of Integrated Water Resource Management. The City of Windhoek identified 3% growth in water consumption over the next 18 years as an acceptable annual growth rate. Their main aim is to keep the growth rate of water consumption within this limit. I believe however that they should also aim to sensitise the public towards water consumption in such a way that it permanently change water behaviour of all residents in the city.

In the following sections, I will briefly analyse aquifer recharge and water demand management further and follow it up with key conclusions and recommendations.

8.1 Aquifer Recharge

Recharge of the Windhoek aquifer is an excellent strategy and is a very effective way to store water. It is by far the most promising supply augmentation scheme in Windhoek. It is a very unique strategy and could prove to be very helpful in future water provision. Especially when considering the extremely high evaporation rate of the area, there is no other way that water can be stored in a more efficient way. It is however a very expensive project, but the City of Windhoek has committed themselves to complete the project as it is still by far the cheapest form of supply augmentation.

One downside to aquifer recharge is that the water will be very vulnerable to contamination because of rising groundwater levels. Special care therefore needs to be taken to fully preserve this as a water source for future abstractions in times of limited other supply. The City of Windhoek however, seems to be fully committed to take the necessary precautions to not only protect the water from contamination, but to also ensure that the quality of the water is not undermined with the recharge of water from other sources. This commitment is highlighted by the fact that 2 hydro-geologists recently were appointed by the City of Windhoek to specifically perform this task.

It is clear that the Windhoek Aquifer, in addition to supplying water to the city through its natural recharge capacity, will also form an integral part of the bulk water supply to the city. The aquifer infrastructure is currently owned and operated by the City of Windhoek while the major portion of the bulk water supply infrastructure in the city is owned and operated by NamWater. It is therefore essential that the management of the system be properly coordinated between NamWater and the City of Windhoek to ensure the optimum utilisation of the available resources and infrastructure and to ensure the optimum benefit to the consumer as well as the country.

8.2 Water Demand Management

The water demand management strategy used by the city is certainly a very good initiative. It helps reduce the wasteful use of the resource, and this is an area that has some room for improvement. The fact that it was only actively pursued during times of shortage clearly shows the potential to save more water on a permanent basis using this strategy. The key lies in making responsible use of water a way of life in every household in the city. This should be the case even in years when enough water is available. Being the cheapest option to stretch available resources it is strongly recommended that the City of Windhoek pursue Water Demand Management also in non-shortage years. This will effectively also help to maximise use of the groundwater bank. If artificial recharge is to be made even more cost-effective, the storage of excess, lower value water, which is available in high rainfall years, must be maximised as use for high-value water during drought years.

Water Demand Management is unlikely to be effective in the long term if it does not receive consistent attention from the City of Windhoek and is not monitored constantly. The ability of Windhoek's residents to improve water efficiency is well evidenced by drought period responses. Unfortunately the City of Windhoek's Water Demand Management policy has generally only been actively pursued during time of shortage. The continuous implementation of the integrated approved policy needs to be strengthened. During my interviews, I picked up a neglectful attitude among WDM personnel in the sense that they seem not to be too concerned if these policies are not adhered to in times when enough water is available. They argue that the water will in any case evaporate from the storage dams. They see no need in trying to save water in times of abundance only so it can evaporate.

I personally have a problem with this attitude and feel that this is exactly where there is big room for improvement within the WDM division of the City of Windhoek. To only enforce policies of WDM in drought periods, the public become used to irresponsible and wasteful consumption patterns. They then need to adapt their water behaviour from scratch every time there is a water crisis. The urgency of the matter is exaggerated by the erratic nature of rainfall in the central area which may lead to the occurrence of this so-called water crisis sooner than anyone may expect. People need to constantly be aware of the water sensitive situation in which they live and of the long-term benefits of responsible water use.

I believe more attention should be given to public campaigns as part of WDM to constantly sensitise the public. The objective of a public campaign should be to inform the public as to:

- Why water demand measures are to be taken
- What will happen if they are not taken
- How the public can help with implementation
- What the City of Windhoek is doing to help

Campaigning should start with a public survey, questionnaires and reaching affinity groups. The next step is to reach the public through advertisements, television, radio, leaflets, public presentations, seminars and via water bills.

Actors that should be taken into account when wanting to start a public campaign include the water users, suppliers of material, the people who educate the community and the government in general.

The water users are those who the City of Windhoek will have to try and reach in order to make them aware of their water consumption and the possibilities that are available to use water as efficiently as possible.

The suppliers of materials and the sellers thereof may also play an important role in the public campaign since they are the ones in direct contact with the consumers. By informing the suppliers of water efficient equipment and the advantages thereof, this information can be passed on to the water users. So in a sense, the suppliers of materials and the sellers become the people who educate the community. However, these suppliers should not be the only ones to educate the community. People, who have knowledge about the Windhoek water system and about ways in which water can be saved and the importance thereof, should be found in order to assist in educating the community.

Educating the community cannot be successful if full awareness of the water situation is not realised at all government levels. That is why it is important for the City of Windhoek to focus on educating and sensitising the central government in general. The City of Windhoek do not only have to make sure that there are actually people who can educate the community, but also needs to be aware of what it should inform the public about.

Further public campaigning will have to include:

- Information about block tariffs to users (how the block system works and why it is set up in this way)

- Information about how the user can control prices and billing (by teaching how to read water meters and comparing own readings to bills)
- Informative billing (use of statements by CoW to provide information to users)
- Information as to how users can lower their consumption
    - About water saving technologies
    - About water saving practices
    - How to detect water leakages on premises
    - How to reduce/prevent leakages
    - Who to contact to repair leaks if not possible to do it yourself
- Information about reporting leaks on the CoW water mains

If people are aware of what they can do to reduce consumption then they may actually pay more attention to their consumption and realise what effect their consumption has on the water system as a whole.

Application of the instruments, however, should not only be done once and in times of drought. Instead the people need to be constantly sensitised. A very effective way to do so would be to actively pursue water education at schools. In this manner a younger generation is being made aware of the water system, the scarcity of the resource, their water consumption and how that affects the resource. They could also be taught what they can do to ensure sustainability of the valuable resource. By raising the awareness of children, the City of Windhoek will invest in long-term water awareness.

Water demand management if implemented correctly, can ensure that huge amounts of water are saved. This portion of water that is saved can effectively be used to recharge groundwater so that it can be abstracted in times of shortage. This is the way of integrating water demand management with water supply management and can be a major contribution towards urban water security in the long run.

In a developing world, cities are composed of two systems, the formal and the informal. The formal system constitutes the planned areas where public water services are available. The informal system is the unplanned areas often characterised by squatter areas, and where public water services are limited or lacking. The attempts to supply households with water and to control the increasing demand for water are many, but the reality is that governments are confronted with escalating poor urban populations. This phenomenon is pertinent also in city of Windhoek and depicted in this case study, it is clear that the strategy of WDM is aimed only at middle- to high-income areas. My concern is that informal areas in the city are not really targeted when it comes to measures of WDM. Apart from community based plumbers (which did not work), no real effort or measure exist to target these areas. One must however keep in mind that this is the section of residents that use the least amount of water per capita (only 69 – 140 litres per capita per day), but it is also important to note that this is the fastest growing section of the city. I would suggest that more deliberate efforts be made to address this section of the city in terms of raising awareness to encourage the responsible use of water in order to prevent the needless waste of the resource.

9. Conclusion

The provision of safe drinking water and the securing of urban water supply is an ongoing responsibility facing cities worldwide. As depicted from this study, the high rate of urbanisation in developing countries exerts an enormous pressure on the natural availability and the sustainable provision of this service to informal areas in particular. This is especially true for African cities where authorities struggle to cope with this and other problems associated with high rates of urbanisation. The provision and delivery of potable water is made even more difficult by the deteriorating quality and quantity of the resource. Many African cities are loosing huge amounts of treated water due to leakages, wastage and illegal connections, which in turn results in a significant loss in revenue. African cities therefore find themselves in a predicament as far as water provision is concerned and the effective management of the resource is highly relevant in most of these cities. What complicates the task of managing water supplies is the fact that most of the fastest growing urban areas in Africa are situated in water stressed or water scarce areas.

Windhoek is such an African city that does not have the luxury of permanent fresh water bodies in close proximity of the city. This is the most important reason why water authorities in Windhoek have gone to such extremes to provide water for its residents. As is the case in many African cities, water authorities are not only occupied with finding alternatives to boost supplies, but are also faced with the challenge to meet a rapidly increasing demand. By using the concept of integrated water resource management, the City of Windhoek is doing an excellent job attending to this problem. Interviews with engineers and planners involved with water planning revealed their total commitment to the integration of all dimensions of IWRM in their quest to secure the supply of water to the city.

The City Council of Windhoek recognizes the vulnerability and scarcity of the resource and is constantly occupied with planning and management strategies to ensure the sustainable use of the resource. The strategies used by the city renders it unique in terms of water supply to its residents. Windhoek is the only city in the world that use reclaimed water for domestic use and has gone to great lengths to implement Water Demand Management principles in order to cope with the limited supply. The city of Windhoek still has a lot to learn with vast scope for improvement, but at the same time presents a noteworthy solution in many respects for other cities finding themselves in a similar predicament.

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Appendices

Appendix A: Rainfall statistics in Windhoek from 1961 - 2004

Year	Rainfall (mm)
1961	1021.4
1962	241.4
1963	695.7
1964	225.2
1965	330.9
1966	423.5
1967	370.6
1968	289.0
1969	253.7
1970	305.3
1971	299.1
1972	366.0
1973	303.4
1974	539.8
1975	315.0
1976	354.4
1977	266.0
1978	200.6
1979	245.7
1980	307.6
1981	85.4
1982	93.7
1983	163.6
1984	137.9
1985	225.5
1986	303.8
1987	220.3
1988	318.3
1989	162.1
1990	319.1
1991	364.2
1992	212.2
1993	256.6
1994	280.1
1995	160.3
1996	222.6
1997	486.2
1998	187.6
1999	537.5
2000	600.6
2001	497.4
2002	307.1
2003	343.0
2004	608.6

Source: Namibia National Weather Bureau, 2005

Appendix B: Historic and Forecasted Water Demand

Year:	Total (m^3)
1967	5,739,830
1968	6,637,765
1969	6,328,556
1970	6,273,353
1971	6,912,097
1972	7,532,290
1973	8,256,949
1974	7,813,951
1975	9,370,310
1976	9,149,326
1977	9,628,948
1978	9,790,682
1979	10,813,429
1980	11,444,039
1981	9,559,999
1982	8,743,699
1983	9,589,690
1984	10,975,888
1985	11,198,683
1986	11,738,262
1987	13,474,762
1988	13,885,384
1989	15,210,495
1990	15,523,383
1991	17,630,839
1992	17,832,371
1993	16,630,740
1994	18,967,480
1995	17,913,286
1996	15,172,357
1997	15,516,157
1998	17,930,863
1999	18,025,207
2000	18,201,121
2001	19,606,849
2002	20,752,225
2003	20,216,420
2004	19,933,042
2005	21,059,782
2006	22,180,000
2007	22,730,000
2008	23,290,000
2009	23,800,000
2010	24,300,000
2011	24,820,000
2012	25,350,000
2013	25,890,000
2014	26,440,000
2015	27,020,000
2016	27,590,000
2017	28,190,000

2018	28,800,000
2019	29,430,000
2020	30,060,000
2021	30,720,000

Source: R.P Steynberg, City of Windhoek, 2005